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# Interservice/Industry Training, Simulation and Education Conference

Abstracts

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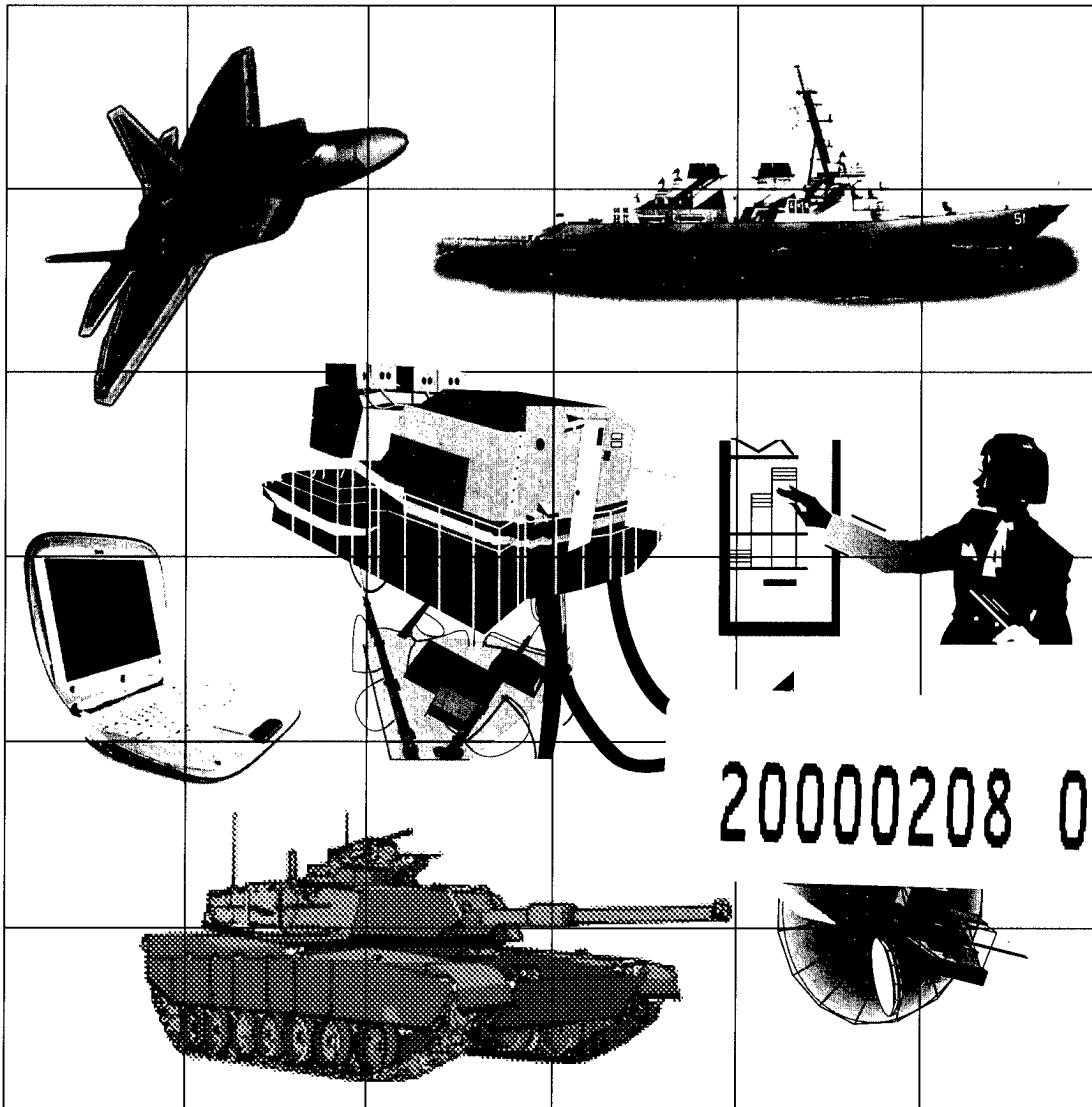
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DISTRIBUTED VIRTUAL TRAINING APPLICATIONS FOR EDUCATION OF MAINTENANCE AND SERVICE PERSONNEL

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This paper describes the application of VR-based computer simulation in the field of practical training. It introduces a training application that is currently under development. The training application is designed to reduce the need for practical training with the actual object. The main objective of the project is to develop a general modeling methodology that can be utilized in a wide variety of scenarios, while minimizing the need for programming simulation source code. Added benefits, such as reduction of traveling costs and time needed for travel, can be achieved by the utilization of distributed simulation following the High Level Architecture standard.

SSAI

REENGINEERING THE INSTRUCTIONAL SYSTEMS DEVELOPMENT (ISD) PROCESS MODEL TO FACILITATE COST EFFICIENT PROCESSES

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Subject matter experts (SMEs) arrive at NETPDTC to review and revise Training Manuals (TRAMANs) and Advancement Exams. Using the model of the traditional instructional systems development (ISD) process, a Navy Chief SME, working with a team comprised of an instructional designer, instructional developer, a graphic artist, a videographer, a programmer, and an editor, will tackle the ordeal of producing a paper-based product with a shelf life of 5-8 years. The current production process averages 2-3 years. To reduce this burdensome and time-intensive process and to produce courses that remain relevant in the ever-evolving technology of Navy warfighting systems, the Naval Advancement Center (NAC), a department of NETPDTC, re-engineered the design and development process. NAC looked to industry to provide best re-engineering practices and developed the Reusability Architecture. The Reusability Architecture incorporates conceptual and modularized reengineering of the design and development processes associated with training products. It is the warehousing of the lowest common knowledge structures (text or media) in a massive database, which may be manipulated by the training need or the end user. The formulated Reusability Architecture populates a database accurately and rapidly, and facilitates output in a number of formats. By reengineering the design and development process to maximize the utility of databasing knowledge structures, the SMEs can now move fluidly between the two major assignments of TRAMANs and Advancement Exams. The development process, for the non-authoring members of the team, is transparent. This paper presents training course development model concepts and the newly developed reengineered design model, using an example from business' best practices for re-engineering processes. The paper then provides a brief overview of the Reusability Architecture and how SMEs can use it to simultaneously develop and design new courses and Advancement Exams. The new process uses four fewer personnel per team by providing advanced electronic performance support tools that combine many of the previously distinct personnel functions. The Reusability Architecture also provides fully functioning rapid course prototypes in about two minutes, a significant reduction over the previous process.

DEVELOPING TOTAL TRAINING SOLUTIONS FOR COMPLEX MILITARY AIRCRAFT SYSTEMS

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Military organisations are demanding an ever-increasing range of training services in support of complex and modern weapons systems. Industry has responded with a number of innovative and cost effective solutions to ensure both affordability and operational effectiveness. These innovative training solutions apply to a wide range of training systems, developed to meet specific training needs, which may be installed within dedicated training facilities. The systems range from desk- top Personal Computer Based Trainers, through to Full Flight Simulators for aircrew, and sophisticated mechanical and electrical systems trainers for maintenance crews. Their effective application not only depends upon a good system design, but also upon the quality of associated courseware, Training Management Information Systems (TMIS) and instruction. Recent experience has shown that the most cost effective solutions make maximum use of low cost devices and part task trainers to ensure that higher cost items, such as flight simulators, are used to their full effect. These solutions accommodate high student throughput and deliver a high standard of training. Training for complex aircraft systems is not only required to support equipment being introduced into service, but must also be delivered and maintained throughout the operational life of the equipment. The delivery and maintenance of training has traditionally been the responsibility of the military operator. However, this situation has changed significantly in recent years, with the Military making ever increasing use of Industry to deliver training. In the UK, military training has recently been contracted under the Private Finance Initiative (PFI), whereby Industry owns the training equipment and delivers training to the Armed Services for the life of the equipment.

THE ARMOR CAPTAINS CAREER COURSE: THE ART AND SCIENCE OF MOUNTED WARFARE VIA THE INTERNET

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Training the art and science of mounted warfare to its soldiers presents significant challenges for today's Army in an environment of constrained resources, expanding missions, and unit reorganizations. The traditional "best practice" for this learning is a multi-month resident program of instruction, with an alternative correspondence program for those unable to attend resident courses. Understandably, correspondence programs cannot offer the same depth of learning in the "art" of mounted operations as resident courses because the interaction of small group instruction and peer collaboration cannot be duplicated. For various reasons, correspondence courses are often the only viable option for most Reserve Component soldiers, giving them little opportunity to fully develop the range of complex abilities demanded by mounted operations. To address this dilemma the U.S. Army Armor School at Fort Knox, Kentucky, has established a dynamic, innovative program to deliver both the art and science of mounted warfare to a diverse, sophisticated, and widely dispersed student population using learning technologies. The Armor School applied lessons learned from operational tests of various distributed learning methods to create a student-centric, open learning environment that provides a model for future military distributed learning courses addressing similar content. This paper describes the conception, development, implementation, and evaluation of the Armor Captains Career Course, used to qualify Reserve Component officers to command and serve in the mounted arms.

DOWN THE DIGITAL DIRT ROADS: INCREASING DISTANCE LEARNING ACCESS WITH HYBRID AUDIOGRAPHICS

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Distance learning has the potential to enhance individual competency and military unit readiness by delivering learning where needed and when needed. However, this requires the distance learning systems to be highly accessible. Many potential classrooms, learners and organizations, especially those in the Reserve Components of the Armed Forces, don't have direct access to the Information Superhighway. Instead, they live down the equivalent of digital dirt roads. The proliferation of low cost personal computers capable of rendering high quality graphics, adoption of international standards for multimedia conferencing, ubiquity of Internet access and universal telephone service have created the opportunity to deliver scaleable, low cost multimedia instruction down the digital dirt roads with the hybrid audiographics approach. This approach delivers high quality audio over telephone lines and data interaction over packet switched Internet connections, thus distributing the transmission load between two highly accessible but limited bandwidth media. This paper explores the need for hybrid audiographics and describes a study comparing the performance of groups of Reserve Component soldiers taking an introductory course on Information Operations via the following modes: (1) hybrid audiographics, (2) hybrid audiographics with video of instructor and (3) traditional face to face classroom. The study results suggest there is no difference in student learning performance between the hybrid audiographics mode of instruction and the traditional classroom for the Information Operations course. The results also suggest video of the instructor had no effect on learning performance as measured by self assessment or actual test grades. Just as important, the typical transmission costs associated with delivering hybrid audiographics were calculated as approximately 4% of the cost of two-way full motion video using Defense Information System Agency services.

DISTRIBUTIVE LEARNING PLUS A look at re-configurable curricula

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The education and training communities of academia, government, and business are being presented with a vast array of software and hardware tools to help carry out the mission of teaching and training. The acceptance and use of the new educational technologies in the education and training arena has been enthusiastic, especially considering that these sectors are traditionally regarded as being among the more resistive to change. The availability of these new technology based tools has served as a catalyst for the creation of new academic and commercial enterprises. We are now entering an area where faculty and trainers and the management at the more mature organizations (in terms of using educational technologies) understand and have developed a level of comfort with what the technologies can do. As a result, there is an increasing focus on the question "what can I do with the technology?" and the responses to this question are opening new horizons. When the focus shifts to what can be done with technology, attention begins to center on what could not be done before. The current paradigm is then challenged, and enhanced effectiveness as well as efficiency are the anticipated results and payoffs.

NEW INSIGHT FOR TRAINING DEVELOPMENT OF 21 ST CENTURY ADVANCED WARFIGHTER TRAINING

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Distributed Mission Training (DMT) opens a new horizon for advanced warfighter training. At last, the dream of training multiship warfighter interaction in a synthetic combat environment is now achievable. It will also soon be possible to train disparate forces across multiple geographic locations in preparation for our Air Expeditionary Force. With this enhanced training capability, the question becomes, How can training development take advantage of this new capacity for advanced warfighter instruction? The answer must acknowledge the fact that training development for advanced warfighter training is much more than developing master task lists, writing objectives, and meeting qualification standards. While DMT may be the most advanced technology in the world, it requires a shift in training concept to fully utilize its potential. Since DMT learning occurs at high conceptual levels, including the interaction of tacit knowledge and metaskills, cognitive task analysis techniques must be used to identify the intellectual skills and cognitive strategies that complement the motor skills, verbal information and attitudes at the intuitive skill level of the expert combat pilot. A new holistic skill hierarchy must be developed to guide the building blocks of instructional design for DMT. This will make it possible to select instructional strategies that take full advantage of an ability to immerse a warfighter in a full-up, simulated combat environment. Similarly, it will also be possible to design scenarios that can train situational awareness in three-dimensional space, identification of friend or foe, relationships of multiple air and ground entities, and response to known and unknown threats. This will result in a level of readiness never before achieved through combat training. This paper presents a methodology for developing this kind of DMT advanced warfighter training for the 21 st century.

RESEARCH AND DEVELOPMENT OF INTELLIGENT TUTORING STRATEGIES FOR U.S. NAVAL RECRUITS

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Since 1990, the attrition rate of U.S. Navy recruits has increased significantly. While psychological disorders are the most significant cause of attrition for females, males separate primarily for disciplinary and legal offenses. Naval training experts have long realized that academic difficulties are often manifested in problem behaviors that lead to separation. The Navy also recognizes that their operational and training environments are male-dominated, and there is a growing concern that gender integration in training has not been appropriately addressed. To stem attrition, maximize the acculturation process, and align training to address Fleet requirements, the Navy is developing and testing new instructional strategies and pedagogical practices.

The objective of this research effort was to increase the academic success of female recruits in a technical aspect of recruit training, where historically female recruits have performed less satisfactorily than male recruits have. A multimedia Interactive Courseware (ICW) instructional intervention called the Advanced Organizer (AO) was developed and tested in the context of firefighter training, to provide a structure for acquiring and storing technical material. The AO utilizes an intelligent tutoring strategy, where behaviors which reflect a student's cognitive learning style are identified and accommodated.

Data was collected at the Recruit Training Center in Great Lakes, Illinois, with over 1,000 recruits participating in the study. Results indicate that the AO decreased stress and made a significantly positive impact on the academic success of both male and female recruits.

AVIATION MAINTENANCE TRAINING CONTINUUM SYSTEM (AMTCS) SOFTWARE MODULE (ASM): AN INNOVATION IN NAVAL AVIATION MAINTENANCE TRAINING

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The Aviation Maintenance Training Continuum System (AMTCS) was established to address fundamental issues with reductions in funding and manpower, and lack of formal standardized technical training for sailors and marines beyond the schoolhouse. The AMTCS is comprised of all training and associated infrastructure required to support Naval Aviation Maintenance training. The AMTCS Program provides training and training management tools in the form of interactive courseware (ICW), computer managed instruction (CMI), computer aided instruction (CAI), and the AMTCS Software Module (ASM) to satisfy just-in-time training requirements for the individual technician, and the organization.

At the heart of the AMTCS is the ASM. The primary objective of the ASM is to enhance the quality and efficiency of training at the Schoolhouse and in the Fleet by providing the capability to identify individual maintenance task requirements, perform real time assessment, identify training deficiencies and provide immediate and focused access to training tools. The ASM is a software application tool designed to track technical training exposure across an individuals military career, validate knowledge/skill for all Navy and Marine Corps aviation maintenance personnel, and provide a feedback system to the decision makers to better manage the training business process. This paper will present the functional capabilities of the ASM and the operational concept of the ASM in Aviation Maintenance schoolhouse and fleet environments.

When fully implemented the ASM will be deployed to all Naval, Marine, and Reserve Aviation Maintenance activities. At present, the ASM is deployed at Naval Aviation Maintenance Training Group Detachments. Next year, the ASM will be implemented in F-14, F/A-18 and E-2/C-2 Fleet Squadrons. This paper will include an analysis on the effectiveness of the ASM based on initial feedback from Schoolhouse and Fleet users.

APPLICATION OF COMMERCIAL PERSONAL COMPUTER GAMES TO SUPPORT NAVAL TRAINING REQUIREMENTS: INITIAL GUIDELINES AND RECOMMENDATIONS

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The Department of Defense has been implementing a number of commercial PC simulation games to support surface, subsurface, and battle group individual and team tactical training. Many of these low cost games offer realistic and accurate graphical and dynamic depictions of U.S. and foreign surface ship, air, and submarine platforms. In addition, the sophisticated 3-D visualization, challenging tactical scenarios, and the high level of interactivity presented in the current generation of PC games is appealing to today's computer-literate young officers and enlisted personnel, creating a potentially effective learning environment. Conversely, features added to some products to increase entertainment and gamesmanship for the broader commercial audience may misrepresent actual combat situations, conditions, or available information that could adversely impact potential training value. This paper examines the advantages and disadvantages of using commercial PC games for naval training applications and offers recommendations and guidelines for integration of these products into Navy training curricula.

SIMULATION COUPLED WITH CBT CREATING A COMPREHENSIVE TRAINING TOOL THAT POTENTIALLY INCREASES TRANSFER

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Selective use of simulation in CBT increases training effectiveness. Simulations in CBT increase training effectiveness by presenting situations in the same manner as they are experienced in the real world. This increases learner transfer. However, simulations alone are not enough. While simulations allow the user to practice what-if scenarios, they lack content and instruction of proper methods and application. Without content and instruction for the user to access, misconceptions can result. Therefore, an effective CBT should have simulations paired with instruction; preferably, interactive lessons designed to help the learner with specific problems and topics.

An approach has been developed using three different techniques for implementing effective simulations for CBTs: (1) Visual Simulations, (2) Modeling Behavior Simulations, and (3) Re-engineered Application Simulations. The first category uses bitmaps of the graphical user interface to mimic the way the application looks. This is a rudimentary form of simulation. In using this method, a trainer shows a series of actions and computer reactions, thus allowing the learner to see and also manipulate the interface. A second category models the engineering of the original application on another platform. Often requiring reverse engineering to simulate the device behavior, it allows the users to manipulate the interface just as they would in a real situation. It operates and reacts just as the actual system. The third category uses the actual code used to create the original application in the simulation. The users interact with the system the same as they would in the reverse engineered model, but the cost of production of the simulation would be minimal and, in fact, allow the training simulation to be as up to date as the actual application.

In this paper, the benefits and limitations of each type of simulation will be analyzed ending in a proposal matching instructional goals with each form. After all, the goal of training is to attain a desired performance. The range of simulation technologies gives an instructional designer or trainer a choice. It is not always necessary to implement the latest and flashiest of software. By matching effective instructional values with the appropriate technology, training can be more efficient and effective.

DESIGNING FOR CHANGE: A MODELING AND SIMULATION SYSTEM APPROACH

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Training simulation systems for the 21st century are growing increasingly more complex. They are characterized by being multi-role, i.e., "what do I want to train today", rather than a point design aimed at solving a specific training need. In addition, these systems are no longer viewed as being a final design at Initial Operating Capability (IOC). Instead, they must continue to evolve and adapt to changing requirements over an extended period of time. This paradigm changes the approach to effective system design. This paper discusses an approach to developing a flight simulation system intended to meet a changing training environment.

Changes that drive the evolution of a simulation system design originate from changes in:

• Mission
• Requirements
• Technology

An approach to addressing changing missions is through the mapping of the mission to a Concept of Operations (CONOPS) that describes how all of the components work together to achieve the training objectives. This approach provides a broader perspective of mission needs that highlights the interaction and correlation between components. An approach to addressing changing requirements is through the mapping of system requirements to the system design. This approach supports a flexible modular design. In the past, networking of flight simulation devices was a simple linking of integrated devices. In the future, systems components which are normally integral to a training device, such as electronic combat environment (ECE), natural environment, instructor operator station (IOS), are broken into separate simulation system components that can be flexibly configured to "build" the simulation system to support any training mission need. The end result is a totally modular and distributed simulation architecture in which every component is equivalent to a system in itself. This architecture places greater emphasis on understanding and facilitating the integration, interaction and correlation of the simulation system components.

An approach to addressing changing technology is by mapping of technology to the system architecture and performance requirements. This approach provides the visualization necessary to develop effective long-term technology incorporation by identifying optimum targets of opportunity to maintain concurrency, circumvent obsolescence, enhance training effectiveness and/or cost effectiveness.

INFORMATION TECHNOLOGY ADVANCES WILL SUPPORT ADVANCED DISTRIBUTED LEARNING ANYTIME AND ANYWHERE

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Information technology advances will support advanced distributed learning anytime and anywhere. However, similar advances in learning technologies are required to achieve cost-effective readiness and enhanced job performance. Adaptive learning that accommodates mastery differences in individual learners also offers benefits of high media reuse for continuum training - initial, refresher, remedial, and just-in-time instruction and performance aiding. High media reuse also can accrue from multiple courses supporting curricula related by personnel, equipment, or domain/core skills.

The Office of Naval Research (ONR) sponsored a Dual-Use Applications Program (DUAP) through the Naval Air Warfare Center Training Systems Division (NAWCTSD) to further "Artificially Intelligent Tutoring for Advanced Distributed Learning." A competitive procurement resulted in a technical investment agreement with Asymetrix Learning Systems, Inc. and Sonalysts, Inc. to enhance existing technologies and commercialize the resulting product(s).

The technical approach creates and delivers an individualized education plan at run-time. The first level of adaptivity determines "what to teach" by selecting and ordering the presentation of topics (that correspond to learning objectives). Topics are selected based on course definition data consisting of instructional groupings (course, module, lesson, etc.), instruction and testing strategy, and prerequisites, as well as current learner mastery. The second level of adaptivity determines "how to teach" by selecting specific learning objects (that support specific objectives/topics) based on student characteristics, mastery, and instructional history. Learning objects are data files consisting of one or more frames and associated media references that are attributed with objective/topic, detail level, score-based criterion, learner population.

After reviewing instructional issues, the paper also addresses the mechanisms, processes, and lessons learned from the DUAP technical investment agreement including Government goals and objectives. In addition to user-community involvement and program management from NAWCTSD, representatives from the Office of the Secretary of Defense, and Defense Acquisition University participated in working groups to evaluate progress and interim products, and to consider changes in instructional design processes to exploit adaptive learning capabilities.
The paper concludes with the implications for linking of adaptive learning capabilities to simulation-based tutors, embedded performance support, and learning management systems. Specifically, the learner model architecture is compatible with several simulation-based tutors, objective-based scenario generation, and training evaluation tools that have been developed under NAWCTSD training research programs.

AUTOMATED PRODUCTION OF REUSABLE LEARNING OBJECTS

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Creating reusable Interactive Multimedia Instruction (IMI) learning objects for diverse delivery environments is extremely important in today's training systems. Expectations for IMI production require specific standards of reuse, or the ability to combine existing learning objects from varying courses, to create new courseware without re-purposing. In addition, expectations are high for building learning objects once, but delivering them in Internet, Intranet and stand-alone CD-ROM environments. Reusability and variable delivery environments are two of the most important issues to consider when building learning objects. Both are separate, yet intertwined, and must be addressed in order to create true learning objects. Both issues cannot be resolved unless production methods allow standardization in the creation of learning objects, and a procedure to control the functioning of several learning objects linked together as a whole. New COTS technologies are available to produce IMI at a cost and quality only dreamed of previously. As a by-product of this technology, standardization of production techniques allowing reusability and variable delivery environments built into learning objects is now possible.

By using a creative combination of COTS products, anyone can produce cost-effective, reusable, and upgradable learning objects for variable delivery environments. This presentation will cover one such combination of COTS products to produce learning objects in a standardized manner. This combination, which has proven to be successful in several DoD projects, is the use of Allen Communication's Designer's Edge, Asymetrix's Synergy Link, and the Toolbook II Instructor authoring system. This combination allows for the development of reusable learning objects that integrate and function with multiple courseware delivery modes and existing training management system software and hardware. It also enables the creation of new courses using previously developed learning objects.

This presentation will show how instructional designers and courseware developers can design courseware using a highly modular approach, provided by the unique blend of these three COTS products. An entire development process for the creation of learning objects will be presented, to include the building of a visual storyboard using Designer's Edge, and the transfer of Designer's Edge storyboard material into Toolbook II Instructor using Synergy. Special detail on the use of pre-made templates to achieve standardization in programming will also be presented, along with the use of a control module called a system book that allows for variable delivery environments and the recombination of learning objects.

THE NAVY ADVANCEMENT CENTER'S REUSABILITY ARCHITECTURE

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Military downsizing and budget reductions compel Department of Defense agencies to seek effective training interventions, which have great applicability at reduced costs. The Navy Advancement Center's Reusability Architecture is one such technology-based intervention. The architecture features a reengineering of the design and development processes associated with training products. Two very important principles, reusability and maintainability, become an integral part of the philosophy and processes used to develop these products. The use of databases and electronic performance support tools allow the warehousing of the lowest common knowledge structures (text or media) which may be manipulated by the training need or training requirement. This architecture is designed to provide increased efficiencies and could reduce much of the redundancy efforts in training materials production costs. Military downsizing and budget reductions compel Department of Defense agencies to seek effective training interventions, which have great applicability at reduced costs. The Navy Advancement Center's Reusability Architecture is one such technology-based intervention. The architecture features a reengineering of the design and development processes associated with training products. Two very important principles, reusability and maintainability, become an integral part of the philosophy and processes used to develop these products. The use of databases and electronic performance support tools allow the warehousing of the lowest common knowledge structures (text or media) which may be manipulated by the training need or training requirement. This architecture is designed to provide increased efficiencies and could reduce much of the redundancy efforts in training materials production costs.

The first product, currently under development, is the Navy Engineering Training Series (NETS). It is a multi-faceted, multi-media interactive training product. When completed, NETS will contain 18 books designed to present basic Navy occupational standards (OCCSTD) related engineering knowledge common to the mechanical engineering ratings. NETS will eliminate the redundancy of content presentation across ratings and will incorporate the information into a single product delivered primarily by CD-ROM with updates via the Internet. Results of the NETS prototype evaluation will be shared with the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) audience.designed to present basic Navy occupational standards (OCCSTD) related engineering knowledge common to the mechanical engineering ratings. NETS will eliminate the redundancy of content presentation across ratings and will incorporate the information into a single product delivered primarily by CD-ROM with updates via the Internet. Results of the NETS prototype evaluation will be shared with the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) audience.

BENEFITS OF MODERN BATTLEFIELD SIMULATIONS SYSTEMS

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In the face of global cuts in defense budgets, simulation based training has been recognized as a solution that retains competency while reducing training costs. New tasks for armed forces, new scenarios, multinational structures, and restrictions in both financial and personnel resources including those resulting from environmental considerations require new concepts and solutions in the areas of military training, exercises and planning. The resulting loss of the 'reality' in conventional live exercises due to restrictions in the availability of supporting military personnel and other limitations caused by reductions in training grounds must be compensated for as much as possible through synthetic environment and modern simulation technology. Therefore, computer-based simulations, as training tools for effective planning, have become increasingly important.

Modern simulation systems should not have only one application, but should be used for both training and education and planning and analysis. This is important in relation to cost effectiveness and common databases for such areas as mapping, terrain, vehicle characteristics and tactics. Interoperability and reuse of battlefield simulations require the development of simulation systems which take into consideration the HLA (High Level Architecture). This paper will present some experiences that Slovenian Armed Forces have recognized at the field of battlefield simulations and introduction of HLA concepts in the training of commanders and commander candidates, staff exercises and planning.

A TRAINING SOLUTION FOR ADAPTIVE BATTLEFIELD PERFORMANCE

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To meet evolving operational challenges, we must leverage new strategies to train officers "how to think," as well as "what to think," preparing them to succeed in the face of unexpected events. This paper describes a model used for training adaptive battlefield thinking and the experimental program of instruction to implement and test that model with officers at the US Army Command and General Staff College (CGSC). In a recent project--Army Experiment 6 (AE6)--the challenge to provide a training strategy for adaptive thinking was met by a cooperative effort between the US Army Research Laboratory (ARL) and the US Army Research Institute (ARI). Each organization initially responded to the requirement with proposed approaches that at first glance seemed to be diametrically opposed. The operational question became whether we could integrate the approaches to define, train and measure adaptive performance. The two approaches proposed were a Constructivist Advanced Learning model and the Deliberate Practice model. The Constructivist model, an ecological approach to training, and Deliberate Practice, based on a Behaviorist orientation, were surprisingly complementary. A synthesized approach was developed and implemented as the "Adaptive Thinking Program of Instruction" (AT POI) to train brigade staff decisionmaking during execution. Eleven Majors from the Advanced Tactics elective, A308, at the CGSC Officer's Course participated in the experimental course in the spring of 1999. The students participated in exercises with a team of highly experienced military experts acting as mentors. The first part of the instruction concentrated on creating a multi-dimensional understanding of the battlefield and actually used a more tradition instructional approach. The second portion of the instruction was in the form of a capstone exercise. It centered on intense deliberate practice of cognitive skills in an environment designed in accordance with the Constructivist model and the Deliberate Practice model. The process to guide the practice was based on the Constructivist model, and it was also congruent with the Deliberate Practice model. Student insight into battlefield situations was supported in both parts of the instruction by use of a consistent set of themes that have been shown to represent expert perception of battlefield situations, and by simulations to enact and display developing situations under discussion. Performance was compared with that of similar students in a control group who did not receive the special training, but who completed the existing advanced tactics electivecourse during the first half of the AT POI and participated in a traditionally structured capstone exercise during the second half. Performance measurement, consisting of a structured method for eliciting situation assessments, was conducted pre- and post-training for the first half of the course and pre- and post-training for the second half of the course. The performance instrument was adapted from an ARI experimental assessment instrument. Subject matter expert and student assessments of the training were also gathered by means of surveys and interviews. Students who completed the AT POI were found to perform significantly better at adaptive tactical thinking. Better performance was found after the second half of the course only--the intense practice portion. The first half of the course, more traditional in nature, did not produce measurable gains in adaptive thinking. We conclude the paper with recommendations for maintenance of model integrity as this approach is disseminated and with reference to further research and development needed for assessment of adaptive thinking skills.

INTERACTIVE EDUCATION FOR THE 21ST CENTURY: THE ARMED FORCES STAFF COLLEGE AND THE EDUCATION OF FUTURE DECISION-MAKERS

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The Armed Forces Staff College (AFSC) has partnered with Veridian Inc. and other organizations to develop and implement an educational system to meet the needs of America's 21st century warfighters. This Joint Professional Military Education (JPME) program integrates current decision-making technologies, an innovative and thought provoking curriculum, web-based databases, and modern command and control systems into a learning system permitting students to experience and learn from a notional, interactive, 24-hour environment. This learning system will simulate the critical actions students may encounter while serving as members of joint military staffs worldwide, thus preparing them intellectually for future challenges. The goal of this learning system is to provide students a realistic and challenging, information-based setting, supporting both long-term retention of joint doctrine and operational art and focused instruction in special areas of emphasis. This paper outlines the results of the initial 2 tests of this new integrated learning system, conducted during the spring and summer trimesters at AFSC.

MASTER TASK LIST AND CAREER TRAINING PLAN: A TRAINING MANAGEMENT TOOL FOR MANAGERS AT ALL LEVELS

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To develop and implement a new strategy for Navy training requires a fundamental change in the process for determining when and how much the Navy educates and trains its workforce. The goal is to blend "just enough" and "just in time" training philosophies in initial training together with a conceptual shift toward apprentice-journeyman-master relationships. This new strategy for training requires a comprehensive cradle to grave assessment of all the knowledge, skills and tasks a sailor must master for any given Navy rating. It allows then to achieve immediate savings just by identifying and eliminating inefficiencies in training. Training is not, however, the sole responsibility of a single agent within the Navy, but a shared responsibility that requires close coordination. The Master Task List and Career Training Plan (MTL/CTP) process provides a vehicle for this coordination. It also provides a process for distinguishing among Apprentice, Journeyman, and Master level tasks, and for determining which tasks are most appropriate for formal, non-resident, fleet or on-the-job training. Including a process for validating and maintaining a database of these tasks, it provides managers a way to ensure the accuracy of the data and assess the impact of decisions.

The MTL/CTP process is a broad-based, straightforward detailed analysis. It is based on the premise that experts in the subject-at-hand are the best source of useful solutions to the program issues. Emphasis is on use of expert opinion and common sense rather than complex analysis tools. The process is designed to bring resident expertise to the problem in a forum that is well structured and organized, yet encourages inputs and discussions. It can be conducted either in a workshop environment with Fleet Subject Matter Experts (SMEs) as participants, or in an off-line mode where analysts interact individually with experts to assess the impact of proposed decisions. The synergistic effects of SMEs representing all platforms and major fleet components produce superior results. An added benefit is reduced lead-time for implementing resulting decisions. The MTL/CTP process is very straightforward.

USING MISSION ESSENTIAL MOES/MOPS FOR EVALUATING EFFECTIVENESS OF DISTRIBUTED MISSION TRAINING

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Demonstrating the mission relevance of advanced training and rehearsal systems and their focus on training and evaluating warfighter needs is best achieved with objective metrics that can highlight mission performance changes. However, for a variety of reasons, it has historically been much easier to evaluate training in the traditional ways, that is, focusing on student evaluations and end-of-course tests as opposed to examining on-the-job behaviors and organizational or mission success. Student evaluations and learning tests are easy to implement but may or may not be explicitly tied to the overall training objectives. Further, these assessments do not provide any indication of the impact of training on job performance or mission effectiveness. Critical reviews found lack of an integrated system for measuring and assessing training performance, over-reliance on subjective measures of performance, and a shortage of valid, reliable, quantitative performance measures of training effectiveness. This paper highlights initial research and data collected to develop an Aircrew Measure of Effectiveness (MOE)/Performance (MOP) Hierarchical Taxonomy capable of assisting training and mission evaluators. The paper details our approach and provides data on sample mission task MOE/MOP decompositions to illustrate how a taxonomic approach can help diagnose actual aircrew mission performance of both individuals and teams. While this approach shows much promise, many technical obstacles need to be overcome before it can be completed and used routinely in an automated form. We highlight and discuss these technical challenges, propose solutions, and provide an agenda for needed research. Implications and potential future applications of the approach are discussed.

STORYIST CONCEPT DEVELOPMENT TOOL FOR CBT-PROGRAMS

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In this paper we describe a tool focusing on analysis, planning and design of CBT programs, called STORYIST. It is a tool for authoring conceptual ideas. The output is not a ready-to-run CBT program but a design from which users can get various multi-platform CBT programs. The process of designing a course usually involves different disciplines and people: problem-domain specialists, teachers, software engineers, psychologists, etc. STORYIST allows the co-operative discussion and design of projects. The overall structure of the CBT program can be improved version by version in a well documented way. Among the distinctive features of STORYIST are: learning goal- centered approach for the development of CBT programs; simultaneous definition of the problem domain, the content of the course and elements of course structure; evolutionary development of the detailed course program structure; reusability of design or design components; producing multi-platform-oriented CBT designs. Authoring with STORYIST actually means to achieve a step by step convergence of learning goals, learning content, and program course structure. The process of convergence passes through three conceptual phases: Conceptual Outline, Detailed Concept and Storyboard (Script). Finally, the author gets a detailed graphic description of the behaviour of the prospective CBT program and he can navigate by sequential or direct links through the whole storyboard. He is able to define a set of multimedia-oriented learning materials for embedding in the CBT programs and he can easily create layouts for learners graphical user interface. Graphical and textual representation and documentation of design components lead to increased performance of the whole course production and follow-up courses. Authors will be able to change the content and the structure easily, following their own ideas, needs, preferences, capabilities and experience.

PREDICTING NAVAL READINESS BASED ON PERSONNEL VARIABLES

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The ability to accurately measure readiness is a fundamental characteristic of an effective armed force. "Our number one commitment is to the readiness and well being of our men and women in uniform," said President Clinton (Clinton, 1994). However, regardless of the President's often stated commitment to readiness, measuring and maintaining readiness has proven to be an extremely difficult task. Even more alarming, the United States has a track record of being unprepared for its wars (Betts, 1997)

The Status of Resources and Training System (SORTS) is the Department of Defense's automated reporting system that identifies the current level of selected resources and training status of a unit (Joint Chiefs of Staff, 1993c). It assesses a unit's ability to conduct wartime missions. Each unit reports its overall readiness status as well as the status of four resource areas: personnel, equipment and supplies on hand, equipment condition, and training. Based on the evaluation of those four resource areas, the readiness of a unit is reported by assigning "C" levels as shown in Table 1.

ELECTRONIC LEARNING DELIVERY SYSTEMS: A SELECTION MODEL

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Selecting the most effective and appropriate delivery system for the successful implementation of a training project is often an overwhelming task. Many of the existing delivery system selection models available to the training professional are outdated, and do not represent the currently available delivery system options. Electronic technology advancements, and their application to training are bringing complex new media choices to the training professional. Distance learning delivery systems represented in this model include satellite networks, teleconferencing, Internet/intranet networks, desktop multimedia, electronic performance support systems (EPSS), transportable audio/video (i.e., systems relying primarily on physically transportable audio- and videotaped materials), collaborative technologies, and the electronically enhanced classroom.

This model narrows the choices to the system most likely to be educationally, economically, and technologically appropriate. After establishing a working taxonomy, the model recommends four stages of activity. The stages include: 1) The assessment of important overall factors; 2) Rating the importance of many learning system attributes to the training project; 3) Selecting the system that most ideally provides the attributes the model's user has rated important; and finally, 4) Validating the selection by reviewing the final choice against the first stage's overall factors.

ELECTRONIC LEARNING ENVIRONMENTS: DESIGN CONSIDERATIONS

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Pervasive technologies for interactive multimedia uses in education and training have become commonplace. Capabilities of commercially available hardware and software tools are making development issues a problem of the past. However, the purchase and use of technology for technology's sake has become a widespread problem in educational institutions and military and industry training programs. The chasing of technology in order to be considered one of the "latest and greatest" training and education programs has resulted in an overabundance of facilities and locations that have hardware and software that is improperly designed, configured, and installed. This paper presents an overview of historical significance of technology uses in education and training. It discusses new media technologies currently available to include distance learning and web-based training considerations for electronic multimedia classroom consideration, and examines the plethora of equipment and software available. It also examines the problems and solutions associated with designing an optimum presentation and instructional system. Case studies are used to examine return on investment and expandability and portability issues. A sample checklist is provided for consideration when converting to an electronic multimedia classroom environment.

DESIGN AND USE OF EFFECTIVE, HIGH-IMPACT, COMPUTER-BASED ACADEMIC COURSEWARE FOR PILOT TRAINING

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It wasn't until simple-to-use multimedia software tools became available, and Personal Computers (PCs) gained a sufficient amount of computing power, that the viability of using PCs for producing and administering self-paced academic courseware sophisticated enough for training pilots became a reality. Such courseware developed for PCs prior to this time, was little more than the old 35mm slide presentation, only with audio narration instead of a stand-up instructor. Unfortunately, with the powerful multimedia PC tools available today, design and implementation of computer-based, self-administered pilot training courseware has not evolved much past a page-turning affair. As a result, the term CBT (Computer Based Training) has gained a bad reputation in the pilot training world rather than the high tech connotation its name implies.

Boeing entered the world of CBT pilot training courseware in 1989 for its commercial airplane pilot training requirements. They have since evolved the development process and courseware effectiveness, which culminated with pilot training CBT courseware for the 777. This courseware is so dynamic and interactive, that 777 pilot trainees are continually amazed at how the drudgery of the ground school portion (the academics) of learning a new airplane has been made into such an enjoyable, yet effective, learning experience.

The techniques learned in Boeing's Commercial Airplane Group are being incorporated into the F-22 academic courseware for both pilot training and the training of airplane maintainers. This paper shows the benefits of self-administered CBT academics for pilot training when the courseware is designed to the strengths of PCs and multimedia software. It also details the philosophy, rules, and techniques to use for making CBT an effective training tool, not only for academics, but also for testing. For testing, it describes how CBT is used to test a student's knowledge and understanding of a subject by using a real-life, interactive, operational format as opposed to a multiple choice, knowledge-only type format.

ACHIEVING AN ACCEPTABLE RETURN ON INVESTMENT FROM TRAINING TECHNOLOGY

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support learning. Many programs are now using information technology (IT) to deliver training, but in the absence of instructional design principles that match technological capabilities to learning needs, IT systems may fail to improve training effectiveness. One of the most versatile and commonly used IT-based training is interactive multimedia instruction (IMI). The purpose of this paper is to identify general principles for designing IMI that help ensure an acceptable return on investment in this technology. The principles are presented in the form of "General Facilitative Links" (GFLs) that tie technological capability to human learning processes. Examples of GFL application are focused on the type of complex skills that student pilots must develop during aviation training. A substantial proportion of pilot training and other types of complex skill training takes place outside of the operational environment, and this training can directly benefit from IMI when properly designed and implemented. In particular, IMI can be designed with simulation and adaptive components that prepare learners for more advanced training in dedicated simulators (e.g., flight simulators) or with operational equipment. Seven GFLs are identified to guide the design of IMI and take advantage of certain IT capabilities that are not available to conventional training. Each GFL is matched to several "Return on Investment (ROI) Factors" that describe value-added capabilities for training. It is proposed that GFLs will help courseware designers exploit IT capabilities that best

THE USE OF IETMS IN TRAINING FOR MAINTENANCE ENGINEERS

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In this paper the question is addressed how Interactive Electronic Technical Manuals (IETMs) can be used in the training of maintenance engineers. In order to investigate these questions, we adopted the following approach. We investigated the state-of-the-art concerning IETMs and training. An analysis was made of how an IETM could be used in the current courses for helicopter maintenance engineers. Several training scenarios were investigated: Training embedded in the IETM, IETMs as a source for learning materials, and as a tool in the learning process. Demonstrators were constructed showing how IETMs can be used in training. The electronic manual for a helicopter, available in SGML format, served as the source for the development of demonstrators. The demonstrators show that an instructor can develop tailored instructional materials by (re)-using existing electronic materials with standard presentation and word processing tools.

INNOVATIONS IN THE APPLICATION OF MULTI-MEDIA WITHIN SOPHISTICATED TRAINING PACKAGES

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Training providers are applying the power of the latest Personal Computers and sophisticated graphics packages to develop multi-media training systems which are able to meet an increasing number of training objectives. These multi-media packages can reduce the cost of complex training equipment packages by reducing the workload requirement, and hence the number, of higher cost training aids. These package are highly flexible and transportable and may also be available over the Internet.

A powerful application of multi-media in this context has been the development of 'Emulations'. In cases where operators and maintainers are required to develop predominately cognitive skills, the physical replication of systems may be replaced by virtual emulation. This technique uses high resolution computer graphics combined with a high-fidelity software model of the system's functionality to represent the equipment and provide effective practical cognitive training.

The UK WAH-64 Apache Training Service makes extensive use of the Worlds' first front end fully interactive 3-D emulations in its Classroom Maintenance Training System (CMTS). The CMTS includes emulations of the entire WAH-64 aircraft systems to a level sufficient to deliver comprehensive training. The term 'comprehensive' has been used to cover the fact that the emulations will present to the student, through the use of graphics, the same visual stimuli as the real helicopter in terms of the appearance of front panels, LRU's, test equipment displays etc.. They will realistically reproduce the behaviour of the helicopter systems and the test equipment, responding to fault conditions and student input in the same manor as the real helicopter, from a maintainers point of view.

This paper describes equipment emulation and in particular the WAH-64 CMTS, describing how a structured analysis has been used to develop an innovative training equipment solution fully integrated with its classroom environment to deliver a total training solution.

AN INNOVATIVE APPROACH TO FAMILIARIZATION TRAINING USING LOCALIZATION TECHNOLOGY INTEGRATED WITH INTERACTIVE MULTIMEDIA INSTRUCTION

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Familiarization training is provided to crewmembers during pre-commissioning and also during crew phasing. During the familiarization training process, the personnel become familiar with the operation of systems, as well with physical location of all system components throughout the ship. These systems include damage control, engineering, weapons systems, communication and fueling systems. Historically, this training process has required knowledgeable, experienced personnel to mentor the crewman. This training is commonly accomplished through the integration of both schoolhouse and shipboard instruction. Unfortunately, with the impact associated with minimally manned ships as well as with the dwindling training dollars, training alternatives are necessary. The Navy and Coast Guard have recognized a similar training need and have combined resources to examine various training solutions.

This paper explores and evaluates a novel concept for providing self-paced, system-level familiarization training customized to the crewman's individual training needs. It also is flexible enough to accommodate individuals with different levels of expertise. This training is accomplished by determining or directing the location of students relative to a on-board system, then stimulating the correct Interactive Media Instruction (IMI) based on that location. Total concept success is dependent on the location technology, the IMI, the movement algorithm and the interaction between these three factors. This approach to familiarization training offers the promise of dramatically improving training effectiveness, while containing costs.

This research explores multiple methods and enabling technologies for determining relative location, and discusses how they may be used to extend current IMI techniques. Military and commercial applications of this procedure will also be discussed.

PRODUCING COMPUTER LITERACY FOR THE DIGITIZED BATTLESPACE OF THE FUTURE

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Computer literacy, especially the ability for leaders and staffs to use digital command and control systems, is clearly a decisive skill for success in the future battlespace. What is not clear is how best to achieve it. Relevant research findings support the use of a problem-based, student-centered approach in which the use of computer systems is situated in a context similar to the eventual expected performance setting. Whether this approach could be used in US Army institutional training successfully and within the given time constraint was the operational issue. This paper documents a successful implementation of the approach at the US Army Command and General Staff College (CGSC). The purpose of the new training methodology was to integrate tactics education with training on the Army Battle Command System (ABCS) in a Brigade operations course to produce both computer performance skills and tactical competency using the same amount of time previously devoted to tactics training alone. The methodology for this project consisted of a radical redesign of an existing tactics course, including the integration of a previously separate 40-hour computer operator course. The development also consisted of classroom configuration for maximum participation by the students and facilitation by the instructor. The methodology was based on a Constructivist approach to instruction that is described here to replace two existing courses at CGSC. The new program of instruction has shown that this combined training approach is viable at the introductory level, and we believe that it could be effective in both institutional training and unit training. The results of the course indicated that even students who came into the course with minimal understanding of tactics and no understanding of digitized tactical systems could produce high quality military operational products (such as orders and templates) using digital systems from the 147 hours of training. Our recommendations include

- dissemination of this approach to other officer training
- adapting the approach for operator training patterned on this successful experience with officers
- adapting the approach for "in stride" (just in time) training for units who will have to prepare for a wide variety of operational challenges with minimal train up time
- development of a 40-hour demonstration class for decision makers and potential instructors to allow them to experience the gains in computer literacy that can be obtained with this integrated method as part of the strategy for dissemination of this training approach

MEASURING THE CONTRIBUTION OF DISTRIBUTED SIMULATION TO UNIT TRAINING

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Simulation is being expanded well beyond procedure training for individuals and crews to address even greater aspects of training of organizations through the use of distributed simulations. Measuring the contribution of these distributed simulations to organizational training has been difficult. Task performance and teamwork are two general measures that provide insight into the contribution that training in distributed simulation makes toward improving organizational performance. This paper reports findings of a field study of US Army units currently training within the Close Combat Tactical Training distributed simulation system. The research examines unit training within this virtual synthetic environment in terms of improvements in teamwork of the formal unit leaders and, secondly, performance of the unit on common tasks. As a portion of this research, a Navy measure for teamwork was refined for application to this study. Data collected during the field study provides insight into the contribution that distributed simulation may have toward these objectives. The results indicate that statistically significant improvements did occur in specific teamwork behaviors and teamwork dimensions by the unit command and control team. Additionally, statistically significant improvements in unit task performance occurred on specified tasks in the virtual synthetic environment. The implications of the study results and methodology of assessment are discussed in terms of evaluation of distributed virtual simulations for unit command and control teamwork training aswell as unit task performance training.

COMPARISON OF US AND CANADIAN VIRTUAL REALITY SHIPHANDLING

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A comparison of the Virtual Environment Training Technology (VETT) shiphandling simulation at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, FL with the Maritime Surface/Subsurface Virtual Reality Simulator (MARS VRS) development system at the Defence and Civil Institute of Environmental Medicine (DCIEM) in Ontario, Canada found similarities in the technology used by the systems. The basis for these similarities is the natural interaction immersive technology provides for shiphandling. Both systems use a comparable head mounted display (HMD) for the visual scene, however head movements are tracked with dissimilar technology. VETT hardware includes an inertial tracker so that it can meet the requirement for shipboard use. MARS uses a magnetic tracker, allowing for 6 DOF to accommodate for movement used in real world performance. This hardware difference is compared. Necessary environmental fidelity is directly related to training objectives. Both systems create an environment to develop "seaman's eye", a perceptual skill used by shiphandlers. However, due to the differences in the specific shiphandling exercises used in the simulations, the fidelity requirements of environmental cues are different. VETT implements an underway replenishment (UNREP) maneuver, an exercise in which ships operated in close proximity, requiring detailed environmental cues such as waves and wakes. MARS VRS is used for performing training maneuvers completed at safe distances, precluding the necessity of high fidelity wakes. These differences are compared. VETT represents navigational information in numeric/abstract format on an HMD for voice call-up by the student. MARS uses high fidelity and real world representation of actual navigational instruments. The navigational information displays are compared. Unique to VETT is the collection of automatic performance metrics for correlation with subject matter expert (SME) ratings. Some preliminary findings are discussed. Conclusions are drawn regarding the differences in the systems and the implication for design of operational shiphandling training systems using virtual reality HMDs.

COMPUTER-BASED TRAINING IN THE GERMAN NAVY - STANDARDS USED, EFFICIENCY AND EVALUATION

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Increasingly scarce resources, environmental constraints, reduced service times and the equipping of the armed forces with more and more complex and multifunctional weapon systems require the German Navy to make use of state-of-the-art training technology, such as computer-based training (CBT).

This new training method has been introduced at various training facilities of the German Navy since 1993. It is used in special fields like operational training and basic operational training for U 206A/U 212A submarines, mine countermeasures/mine warfare, electronic warfare, electronics training, naval engineering, flight training etc.

The CBT learning programs developed to date are subdivided into modules, chapters, sections and steps and are used in the following areas:
· basic technical training,
· operator training, and
· maintenance training.

The development of these learning programs is preceded by a training analysis and the resulting selection of media with the program objectives and contents described and defined therein. The approach and management of CBT learning program development are specified in a "Guideline for the Development of CBT Learning Programs for the Bundeswehr" for the individual phases.

For armament projects, entire program packages for the training of new weapon systems are developed, e.g. Class 124 Frigate, Class 212A Submarine, Class 333 Minehunter etc. These programs are evaluated within the scope of quality assurance by functional and field tests, user reports and evaluation studies.

KNOWLEDGE MANAGEMENT METHODOLOGY AND TOOLS (HOW DOD CAN BECOME A LEARNING ORGANIZATION)

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Knowledge Management (KM) initiatives are surfacing daily and at an increasing rate. The Department of Defense (DoD) can become a Learning Organization by using many of these KM synthetic solutions in the 21st century. To become a Learning Organization, the DoD needs to implement integrated KM using knowledge bases, KM tools and change management processes, rather than merely implementing information technology approaches. There are indications that individual Services are already moving in that direction. The Navy is "committed to a broad KM effort."(Natter, Feb 99) The other Services are beginning to focus on what KM can do for them as well, particularly in the area of training. To make this transition smoothly, clear definitions of knowledge, knowledge processes, and knowledge management are needed. The author proposes two key paradigm shifts, including Metalevel thinking that dictate new KM methods capable of being embedded in, and benefit to, the entire learning organization culture. This leads to distinct understanding of the impact KM will have on training, as the new framework for all future training. The other new knowledge paradigm, besides metalevel thinking, "the best knowledge to the right person at just the right time," has emerged from the ongoing KM activities. Use of the KM lexicon, and philosophy, allows further analysis of alternative KM approaches in the light of their unique training and knowledge transfer needs.

ACSC DISTANCE LEARNING - 50 YEARS OF LESSONS LEARNED -

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For over fifty years the Air Command and Staff College (ACSC) has provided Intermediate Level Professional Military Education (PME) via Distance Learning (DL) to US and Allied Officers and civilians. The ACSC DL program was initiated in 1948. At that time the only feasible way of delivering instruction to a mass audience was by correspondence. How times have changed! Well, for ACSC DL the times will finally change later this year when the last cycle of book-based correspondence students complete their studies. During these five decades technology has had a profound effect on how we have presented instruction to DL students. Today we provide ACSC PME by three modes to over 8,000 active distance learning students worldwide. These three modes are multimedia correspondence, multimedia seminar and cyberseminar. Our program is rigorous and recognized by the American Council of Education, which recommends the granting of up to 27 hours of graduate level credit across four cognate areas upon completion of any of the distance learning programs. In this presentation we will share what we have learned during our evaluation and application of the various technologies we have employed. Included in these technologies are: audio and video tape, live and delayed television, satellite broadcasting, one-way video and two-way audio, inter- and intranet, etc. Our experiences have shaped our thinking. As we have developed our vision of the future we have considered most to the technologies mentioned above. We want to share this vision with you and describe some of the possible mixes of technology we expect to use to make that vision a reality. One of the more profound lessons learned is just because it is cutting edge technology, it doesn't necessarily mean it facilitates learning. We still intend to use books and other printed matter because sometimes it is simply the best method of presentation. Media analysis still applies!

INSTRUCTIONAL STRATEGIES FOR TRAINING DISMOUNTED INFANTRY IN VIRTUAL ENVIRONMENTS

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This paper describes the results of the first experiment conducted with the Fully Immersive Team Training (FITT) research system. The objective of the experiment was to examine instructional strategies involving how and when to give guidance during team training with Virtual Environments (VEs). 118 college students participated in the experiment. Two-person teams engaged in search missions in VEs depicting building interiors. The teams were composed of either two participants or a participant and an experimenter's confederate. Before attempting missions all participants studied a printed-text mission training manual that described mission procedures and received training on how to move and interact in VEs. Teams engaged in 1 or 2 practice missions and a test mission. Teams were given guidance either before (demonstration), during (coaching), or after (replay) the first practice mission, or not given any guidance at all (Control group). Performance measures included: speed and accuracy of search, communications, and security procedures. Results indicated that the participants quickly learn to use the FITT interface to move in, and interact with, the VEs; and that performance of mission procedures improved with practice. Relative advantages and disadvantages of the instructional strategies, and lessons learned, are discussed.

DISTRIBUTED LEARNING FRAMEWORKS (DLF)

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A Distributed Learning Framework (DLF) is a software architecture or infrastructure that allows the integration of various processes and tools involved in front-end performance analysis, design of instructional interventions, development of component based learning content, network based delivery of content, and management/administration of learning and results.

A DLF operates in network based, client/server environment that may be deployed in an enterprise-wide capacity via the mechanisms afforded by Internet and Intranets.

Furthermore, a large, scalable repository based on relational databases or similar databases can provide an underpinning for integrating and sharing the data between different processes, tools, applications, and learning content. The data repository ensures that the data across different processes is shared and that different projects can share data to avoid redundancy resulting in consistency and time-savings.

SSAI   SSAI

ASSESSING THE EFFECTIVENESS OF SIMULATOR-BASED TRAINING

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The digital revolution has sparked a worldwide movement toward the use of simulators to enhance training and accelerate learning. As simulator-based training grows, the concern of trainers should increasingly turn to determining if effective training is taking place, rather than merely using simulators more extensively. We reviewed the simulator training literature to see just what literature exists as well as the effect simulation is having in terms of training effectiveness. The review concentrated on the literature from several different domains/perspectives, including the NASA space program, commercial aviation training, medical procedures training, and nuclear power plant operation training. The objective of the review was to focus on prototypical studies which showed utility in determining the effects of simulator-based training of highly complex tasks. Unfortunately, our review showed that little attention is being directed toward determining the effectiveness of these training devices and research on the effective tactics and strategies for utilizing simulation are almost nonexistent. We then put forward a brief explanation for the lack of motivation to assess simulator-based training, along with a plea to move forward in this area. Finally, we review a model, first outlined by Lewis (1996), for assessing the effectiveness of simulator-based training.

CREW RESOURCE MANAGEMENT AND MISSION PERFORMANCE DURING MH-53J COMBAT MISSION TRAINING

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Empirical research is confirming that crew resource management (CRM) should be an integral part of tactical aircrew training. This study evaluated the link between CRM and mission performance for 16 MH-53J rotorcraft aircrews during preparation and execution of a complex combat scenario in a networked training simulation. A strong correlation of .84 was obtained between CRM and mission performance. All CRM categories (e.g., mission evaluation, risk management, situation awareness) were highly correlated with mission performance; however, the categories were differentially predictive of mission performance in the various mission phases (communication was the best predictor in mission preparation, task management in infil/exfil, tactics employment in low-level). This study extends the findings of earlier research with MC-130P aircrews, where comparable CRM-mission performance correlations were obtained. Despite differences in the missions, flight profiles, and capabilities of the two aircraft, a number of key CRM behaviors emerged as common across the two weapon systems. As an example, the best crews in both aircraft immediately identified threats while enroute and classified them as "planned" or "unplanned." There were also some notable differences between the two weapon systems. One example is that the nature of communication among the crewmembers differed , with the MH-53J crews exhibiting more general, crew-wide interaction, while communication within the larger MC-130P crew centered around pairs of crewmembers communicating specific information at specific times. A major implication of this body of research is that a core behavior-based tactical CRM curriculum can be tailored to reflect the tactics and unique demands of each individual weapon system. The networked training mission afforded an excellent opportunity to observe important coordination and communication activities within the larger tactical team context. The results underscore the importance of broader team coordination and the need to formally train these team skills.

MEASURING C-5 CREW COORDINATION PROFICIENCYIN AN OPERATIONAL WING

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Air Force Instruction (AFI) 11-290 requires that all operating units use proficiency data to measure the effectiveness of their cockpit/crew resource management (CRM) training programs. In response, the 512th Airlift Wing, Dover AFB and the Air Force Research Laboratory (AFRL) developed an approach whereby the Wing supplied qualified data collectors while AFRL developed process and performance instruments, "calibrated" Wing observers in the use of the instruments, and analyzed the data. Data were collected from 16 C-5 aircrews during a challenging, simulated nighttime airlift mission involving poor weather, post-takeoff landing gear malfunctions, and eventual engine failure. Building on AFRL's established methodology with the MC-130P, two expert observers independently rated CRM proficiency and mission performance using behaviorally anchored, C-5 specific scale elements. A significant correlation (r=.58) was obtained between rated overall CRM proficiency and mission performance, extending the validity of AFRL's approach to another weapon system and mission. The study also yielded a wealth of qualitative data capturing the specific CRM behaviors of successful aircrews (e.g., pilots and flight engineers directly interact to mission plan and solve in-flight problems). Data from the study were briefed to wing leaders who have already implemented the study's major recommendations as a set of training initiatives to improve the mission performance of all aircrews. The study demonstrates that, with nominal outside research support, an operational Wing can establish a valid CRM proficiency measurement program. Lessons learned from this research can be applied across major commands to ensure that all units are able to comply with the CRM proficiency data requirements of the AFI 11-290.

AIR COMBAT TRAINING – THE EFFECTIVENESS OF MULTI-PLAYER SIMULATION

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This paper describes a transfer of training trial conducted on a multi-player desktop simulator used for air combat training and provides an analysis of the interim results. The availability of networked desktop simulation technology means that team training in air combat tactics is now achievable at low cost. The critical test of the effectiveness of such a simulation system is the transfer of training to the aircraft. Whilst previous studies have demonstrated performance improvement in simulator exercises in air combat, up until now, transfer of training to the aircraft has not been demonstrated. A trial has been conducted to establish if such transfer occurs from training in pairs tactics conducted on the JOUST multi-player, desk-top simulation system to the airborne environment. The interim results indicate that transfer of training has been demonstrated. Students trained on the new system exhibited superior performance on a range of behavioral indicators, including communications and tactical leadership.

AIR FORCE C2 TRAINING SOLUTIONS IN DISTRIBUTED MISSION TRAINING ENVIRONMENTS, A REPORT FROM THE SYNTHETIC BATTLESPACE

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Currently, Command and Control (C2) virtual simulations used in training are usually not designed to be interoperable with other distributed synthetic battlespace systems. This characteristic thus makes it difficult to integrate C2 training assets into a full synthetic battlespace. Current systems are designed such that they are not open and have proprietary software thus further complicating the interoperability problem. Scenario generation and control of the synthetic environment have proven to be tedious and cumbersome. Solutions such as strap-on systems to provide synthetic battlespace require significant resources in regard to contractor personnel and role players. A few stand-alone training systems have been developed for the general air defense task. This paper will discuss various advanced solutions including the application of realistic synthetic battlespaces to provide more effective C2 training in the developing distributed mission training environment. Also, the transition of these training concepts to next generation C2 of the 21st century will be considered.

SUPPORTING EXERCISE CONTROL AND FEEDBACK IN THE DIGITAL DOMAIN FOR VIRTUAL SIMULATIONS

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The U.S. military and its contractors are developing digitized command and control systems to provide military units with information dominance over the enemy. Ironically, these digital systems have created training control and feedback challenges for exercise Observer/Controllers (OCs) in all simulation environments. OCs have the responsibility to assess and mentor exercise players on the effective use of digital systems. In addition, OCs must control the exercise. To do this, OCs need the capability to monitor and store all player digital traffic, inject digital messages and display digital information for post-exercise collective learning or after action reviews (AARs). However, today's OC may be unable to monitor player digital communications of key players or may be deluged by information and unable to identify those digital actions or inactions that most affected the training event's tactical outcome.

Under the sponsorship of the Simulation, Training and Instrumentation Command (STRICOM) and the Army Research Institute (ARI), we are developing a prototype training support system to overcome control and feedback problems associated with digitized units. We call the system the C4I Training Analysis and Feedback System (CTAFS). We are developing the CTAFS under our Intelligent-Decision Aids and Training Assistance (I-DATA) concept. We designed the CTAFS prototype to support digitized company team virtual simulation exercises. The first CTAFS prototype monitors tactical digital communications on a LAN and permits the OC to role-play notional units and inject control events into the exercise. Using an expert system, the second CTAFS prototype will alert the OC to significant digital activities and disparities in situational awareness among the players. CTAFS will automate the production and presentation management of C4I AAR products linking AAR displays to established doctrine and standards. In addition, CTAFS will provide the OC with discussion guides to facilitate AAR discussions on what happened, why it happened and how to improve performance.

This paper addresses the challenges of C4I digital training and presents information and lessons learned during our research and development of CTAFS and its AAR capabilities for the C4I portions of virtual simulation exercises. Additionally, the paper explores the role of C4I AAR systems in future C4I training environments.

EMBEDDED TRAINING FOR THE GLOBAL COMMAND AND CONTROL SYSTEM

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Embedded training can enable faster, more effective learning by delivering instruction that is operationally relevant, when and where it is needed. Embedded training is a natural evolution from stand-alone computer based training tools and their proven training methods to the inclusion of those technologies into the internal design of Command, Control, Communications and Intelligence (C4I) systems. The power to link C4I operational displays, data bases and decision support applications to web based, multi-media embedded training support with all its creative potential will profoundly change C4I training, planning and mission rehearsal.

The Global Command and Control System (GCCS) contains versatile tools to develop and conduct computer-based embedded training for tactical mission applications. Embedded training can teach basic skills to new GCCS operators and guide experienced users through advanced functions required to assess tactical situations and make critical operational decisions.

SSAI

THE SIMULATION OF A HUMAN SUBJECT FOR INTERPERSONAL SKILL TRAINING

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We have developed a unique, PC-based training tool that emulates human behavior using a computer-simulated person in a realistic scenario. The tool was developed for the FBI to help agents develop interview skills by providing meaningful experience in detecting deception during interviews. The self-paced, multimedia courseware enhances learning while delivering an effective, relatively low-cost, interactive experience. The interview-training module gives the trainee experience in asking proper questions and distinguishing between deceptive and truthful responses. It also provides a critique and numerical score for the interview. As their skills develop, law enforcement students can see their critiques improve and their scores rise. Since the implementation of the simulation within the FBI, new agent trainees have increased their interviewing practice. This type of training tool supplements and reinforces traditional classroom instruction by giving the trainee an opportunity to practice.

The technology could also be used to help develop a large range of interpersonal abilities including investigative skills and peer-pressure resistance skills taught as part of a drug prevention program.

USING A PROTOTYPE ELECTRONIC PERFORMANCE SUPPORT SYSTEM (EPSS) AND DATA BASE TO CONDUCT A FRONT END ANALYSIS (FEA)

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The purpose of this paper is to describe a prototype Electronic Performance Support System (EPSS) and database used by the Coast Guard to conduct front-end analyses (FEA). This prototype design was based on the model developed by Dr. Joe Harless. The goal of the prototype model is to standardize processes intelligently, capture data, and increase efficiency within the organization through the design and use of a computer program aimed at automating analysis. A key feature of the Harless approach is a systematic process for identifying interventions that support the desired performance of a particular job. This EPSS, developed by the Coast Guard, was originally prototyped in various studies on Coast Guard cutters over a one-year period.

There are three primary benefits to an automated database for analysis. First, the EPSS allows the user to complete new front-end analyses in half of the time that was previously required. A key mission area of the division is to analyze and evaluate data for the purpose of making recommendations for training. The benefit of this program is that more time is allocated to the actual analysis of data versus data collection. Second, the report produced will recommend specific interventions that were automatically selected based on algorithms written in the program. The creation of software that can make performance intervention recommendations enables individuals involved in data collection to survey accomplished performers in a shorter period of time. Third, it drastically reduces the amount of paperwork completed by individuals using the program. The user simply carries a laptop computer aboard the Coast Guard cutter or work site and inputs the data as it is being collected. Previously, data was hand-recorded and typed into a computer workstation. Even then, information had to be copied or re-entered on various forms. There was no "enter once-use many." This was a time-consuming process.

The results of this prototype suggest that electronic support system software can increase the time devoted to analysis of data. The findings from the study have an impact on the methods in which data is collected for the Coast Guard. This paper will present the background, methodology, results, and conclusion of the research, as well as examples from the program. The paper will focus predominantly on the implications of using automated software for analysis and will include areas for future research.

INITIALIZATION OF UNIX BASED SIMULATION EXERCISES FROM THE PERSONAL COMPUTER

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To effectively train in simulation environments, all aspects of mission planning must be considered. This planning can occur in locations far from the simulation site, and can involve any of the following: development of the scenarios expected to be executed, preparation and generation of support products such as the operations orders, maps with overlays, execution matrices, and administrative orders, and initialization data parameters for both the equipment to be used and the simulated battlefield. Today's military planners are becoming increasingly computer literate, however, many trainers do not use simulations often enough to become familiar with the specific exercise planning interfaces used in their simulation environments. Although, simulation has moved much closer to the desktop, seamless initialization will require easier migration of common desktop tool produced products into the simulation. Familiarity of user interfaces for simulation planning and initialization tools can be achieved through the integration of desktop commercial off the shelf (COTS) products already in common use. Most exercise plans originate in COTS products such as Microsoft Office. These plans are then prepared for application to specific simulation environments. The process of exercise preparation is primarily a task of transposing the mission, overlays, and execution matrices from desktop formats into formats compatible with specific simulation environments and can become a time consuming process. Desktop software is now sophisticated and powerful enough to automate this translation of exercise plan information (documents) into simulation formats for exercise initialization. This process involves the transfer and integration of a simulation environment's object model into common desktop tools. The object model must be integrated with the planning tools so that through the course of exercise development, the plan may be captured in a format consistent with scenario generation. Initialization of Close Combat Tactical Trainer (CCTT) exercise units, obstacles, and control measures from PowerPoint will be used as a practical example of this functionality. In particular, the paper will show how COTS products meet user requirements for an automated initialization tool and provide a uniform view of the training and simulation domains for both users and developers.

EMBEDDED STIMULATORS FOR NAVAL ON-BOARD TRAINING

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In many navies, readiness training is moving out of the classroom and onto combatant vessels. This evolution is being driven by two factors: declining defense budgets and the need to improve readiness of combat system team crewmembers. In the past, combat system team training has consisted of two major elements: classroom training and underway training exercises. Both of these training venues come with a host of disadvantages.

Classroom training requires the maintenance of an extensive shore-based training infrastructure; the actual training value is limited by the fidelity of the training equipment. Shore-based trainers typically include equipment and sensor models that only approximate what the combat system team will find on real ships in a real combat environment. This is due to the nature of the shore-based facility; shore facilities must serve as trainers for many ship classes, and shore-based trainer mockups tend to lag the state of the actual combat system equipment by several years.

Underway training in a canned warfare environment with real participants has the advantage of training occurring on real equipment in a real situation. The expense of these exercises, however, severely limits their utility and the degree of realism that can be attained. Declining defense budgets have also severely limited the opportunity to train in this environment.

The alternative training strategy is a blend of classroom trainers and shipboard exercises. An on-board training stimulation system is provided that presents a synthetic training environment to the combat system team on real equipment. This approach combines the best of both worlds. A stimulation system can synthesize complex combat scenarios much like those possible at a shore site and provide training on actual equipment just as sea training exercises do. Furthermore, an on-board stimulation system is available at all times to the crew, even at sea; therefore, training opportunities abound.

The design of an on-board training system is built around a number of building blocks that are dependent on the type of equipment included in the host combat system. Stimulators and simulators are provided for each element in the combat system and are networked together and controlled from a simulation computer. The design of the network that connects the boxes together is such that any complement of boxes can be included without altering the software that executes in the simulation computer. This design is achieved by using a DIS/HLA protocol for the network architecture and providing a DIS/HLA front end to each of the stimulation or simulation boxes. The on-board training system is configurable to any combat system by selecting which stimulators and simulators are needed in a particular situation.

This paper describes the design of a representative on-board training system with emphasis on the radar stimulation building blocks.

ABRAMS/BRADLEY APPENDED CONDUCT OF FIRE TRAINER (A-COFT)

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The Army National Guard's (ARNG) training strategy prescribes the use of a platform-independent, low-cost, PC-based appended trainer to support the Guard's Armor and Infantry forces to train individual, crew and platoon gunnery at the Armory location. The National Guard is accomplishing this by upgrading the current Abrams-Full-crew Interactive Simulation Trainer (A-FIST) with PC-based image generation and developing the Full-crew Interactive Simulation Trainer-Bradley (FIST-B). The identical Instructor/Operator (I/O) console and open architecture allows training support for both combat vehicles at a fraction of the traditional procurement costs. The combination of these training devices has been renamed the Appended Conduct of Fire Trainer or A-COFT.

Application of open architecture technology allows the ARNG to provide increased gunnery training opportunities for individuals, crews and platoons, producing increased unit readiness at a fraction of the time and funding of conventional training methods (list some of these). A common hardware and software baseline to these and other gunnery systems provides the added advantage of reduced lifecycle costs and "welded" upgrades with Army-approved trainers, such as COFT.

The development of the A-COFT program has lead to the reuse of traditional gunnery training matrices while moving away from a hardware-dependent system. The emergence of PC-based technology may provide the groundwork for the utilization of SIMNET to meet the maneuver training requirements of the ARNG. Networked with the A-COFT, the PC-based trainers will provide increased training opportunities at an Armory location, overcoming the distance and time constraints of ARNG training.

LOW COST EMBEDDED SIMULATION SYSTEM FOR GROUND VEHICLES

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The US Army is in the process of developing and demonstrating the technology to incorporate embedded simulation into ground combat vehicles under the Inter-Vehicle Electronics Suite (IVES) and Inter-Vehicle Embedded Simulation Technology (INVEST) Science & Technology Objectives (STOs). Proving the validity of Embedded Simulation (ES) to support multiple ground vehicle platforms will be difficult. Some of the concerns for ES are cost and flexibility of the system. To alleviate these concerns TARDEC is developing an architecture for a low cost B-Kit capable of integrating with multiple vehicle architectures. The B-Kit will be composed of off-the-shelf PC compatible hardware packaged in a ruggedized box. This paper addresses the hardware and software decisions that were made as a part of these integration processes.

BFTT AMN APPLICATION OF STOW TECHNOLOGIES FOR CATEGORY 1 NAVAL TRAINING

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The Battle Force Tactical Training (BFTT) Improvement Program is an in-port shipboard combat system team training capability to provide, a realistic unit level team training in all Navy warfare areas. This training is partially accomplished with stimulation to shipboard sensors via onboard trainers provided by tactical equipment program managers and simulation of non-shipboard forces such as friendly, neutral, and enemy aircraft and submarines. One of the first BFTT Improvement Program components is the BFTT Air Management Node (AMN). The BFTT AMN is designed to provide Air Traffic Control (ATC) and limited Air Intercept Control (AIC) proficiency training. This training is accomplished by integrating DARPA Synthetic Theatre of War (STOW) technologies with the existing BFTT architecture. This combination brings intelligent aircraft and a High Level Architecture (HLA) simulation base to the BFTT arena. This paper will discuss the STOW technologies and the software architecture designed to provide a robust ATC trainer to the fleet.

MOBILE "RANGELESS" INSTRUMENTED TRAINING: MEETING THE CHALLENGE TO SUSTAIN THE READINESS OF DEPLOYED FORCES

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The Navy's challenge to have a robust capability to sustain force power projection while maintaining a flexible response is influencing future training strategies. Concepts of tailored training and "just in time training" to maintain deployed readiness have affected training range design and employment. The Joint Tactical Combat Training Sys-tem (JTCTS) provides the next generation of instrumentation for air combat training. As an integral element of the Navy's overall training and readiness strategy, it is being designed to meet the challenges of the 21 st century. The JTCTS will provide mobile "rangeless" instrumented training worldwide, providing the Service with the capability of maintaining war-fighting proficiency during deployed cycles and optimized training effectiveness during inter-deployment periods. The system will exploit the use of precision GPS localization and distributed simulation technology to create a synthetic environment overlaid on real world participants. Simulated weapon employment and EW threats will provide a dynamic training capability that will enable repeated evolutions of high quality training previously provided only at large fixed range installations. Continuous ground-truth monitoring of participants during the exercise supports an accurate debrief of training events that provides immediate feedback to the trainee. Results can then be assessed and future training cycles planned to focus on key tasks thus optimizing the use of available re-sources. This paper will discuss the operational requirements for next generation training range instrumentation, provide an overview of how the JTCTS has been design to meet these requirements and then summarize the Navy's employment strategy for the system.

LPD 17 TOTAL SHIP TRAINING SYSTEM MAINTAINING PEAK COMBAT READINESS THROUGH CONTINUOUS, AT SEA TRAINING

Dan Masaki and Paul Simpson

Technological advances in computational, network, communication and display systems open the way for cost effective approaches to achieving "Start to Finish" onboard training for the entire ship's crew. Advanced technology training applications are being brought aboard the LPD 17 Class of Ships to conduct a complete range of operations and support training. Success of the on-board training program is ensured through a Training Management System function which provides the tools that facilitate the scheduling of training resources and automates the selection and assignment of training exercises through performance based curriculum sequencing. The Training Management System also facilitates the transfer of training and qualification records of each crewmember and automatically updates these records as the individual progresses through assigned training courses. State of the art technologies in network and communications provide affordable Interactive Distance Learning (IDL) that allow off-board training resources to be used for on-board training. Virtual reality techniques will be incorporated to support training in fighting fires and handling hazardous material spills without risking crew injuries or damage to the ship. Another approach to training is achieved by stimulating ship systems to simulate realistic shipboard situations. In this approach, referred to as organic training systems, the training function is embedded in actual shipboard systems to conduct full fidelity training.

The ultimate training goal of the LPD 17 Total Ship Training System (TSTS) is not only to conduct total ship crew training but also to support embarked troop training. TSTS will be capable of networking a series of appended trainers for vehicles that the LPD 17 class of ships transports in its well deck and flight deck. Embarked vehicles could include AAAV, LCAC, M2A3, V-22, and helicopters. By incorporating Virtual Reality, Interactive Distance Learning, Organic Trainers and interfacing with the Battle Force Tactical Trainer (BFTT), the LPD 17 Total Ship Training System will be capable of conducting not only combined forces team training, but also full scale mission rehearsals.

MICRO-SIMULATOR SYSTEMS FOR IMMERSIVE LEARNING ENVIRONMENTS

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The Chief of Naval Education and Training (CNET) has undertaken the Micro-simulator Systems For Immersive Learning Environments (MiSSILE) project to identify, research, and apply commercial PC gaming and simulation technology as a potential training tool to supplement the development of various warfare skills and tactical thinking. PC gaming and simulation is widely accepted and very familiar to today's students. The PC gaming and simulation industry, driven by recent technology advances and consumer economics, has dramatically driven cost down while improving the quality and realism of games and desktop simulation capabilities. The cost – capability curve available today was unheard of just two years ago. This technology has the potential to be a very affordable way to enhance basic skill development and also allow personnel to practice tactical thinking every day. The underlying theme for the MiSSILE project is to apply a learning methodology to the products and leverage the economics of PC gaming and simulation to improve the efficiency of Navy training.

The University of Central Florida's Institute for Simulation and Training is working with CNET to study the potential offered by this series of technology capabilities and to assess actual training effectiveness through a series of prototype efforts. The initial phase of this effort is to examine the effectiveness of Microsoft's Flight Simulator 98 (FS98) as a training intervention for Undergraduate Pilot Training (UPT). A micro-simulator lab at Training Wing FOUR at Corpus Christi, TX supporting T-34C training will be used as the prototype. This paper will report the results of this study to date, which will formally evaluate the students abilities as measured by a combination of test instruments, comparing student test scores for those who have received the micro-simulator training and those who have not. The learning integration kit used features an add-on to FS98 that integrates and presents Navy aircraft, Corpus scenery, and flights from the curriculum in a controlled learning environment.

CREATING MILITARY SIMULATORS AT ARCADE GAME COST

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In these times of shrinking budgets and increasing equipment complexity, training for major equipment acquisitions requires carefully selected, cost effective life of type solutions. This paper briefly reviews the types of solutions used to provide effective training for complex real equipment. The introduction briefly outlines the advantages and costs of different solutions. The body of the paper provides a case study of a solution developed by SMA for a Royal Australian Navy gun operator training requirement. Our approach has been to exploit popular commercial off the shelf (COTS) hardware and software. In particular, in the area of graphics, we chose to go in the direction of Direct 3D (as opposed to Open GL) because of the benefits of the parent Direct X suite of code, which supports sound, networking, IO, as well as 2D and 3D acceleration. The paper concludes that, although Part Task Trainers are not a simple panacea to all training problems, advances in PC technology mean that they provide a highly cost effective training solution - in fact at arcade game cost.

COMPUTER BASED MAINTENANCE TRAINING IN THE CANADIAN NAVY

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The Canadian Patrol Frigate Project delivered 12 state-of-the-art warships in the early to mid 1990s. Along with the ship's came the requirement to train crews on how to maintain a myriad of new and very complicated combat systems equipment. In the past, as with other navies, maintenance training has been conducted almost exclusively on the actual equipment, either on ship or in a shore based training establishment. This approach has obvious disadvantages, which include the considerable expense of procuring, maintaining and reconfiguring the real equipment to function as a trainer. In addition, student throughput is limited and it is often difficult to simulate real faults in a meaningful way on the actual equipment. With the advent of increasingly more powerful and capable personal computers and simulation software in the 1990's, an alternative has emerged in the form of computer based simulated maintenance training. Under sponsorship from the Canadian Navy, Lockheed Martin Canada (LMC) Ltd has created a distributed, two dimensional simulation to augment current training practices. Installed on networked PCs, the student is presented with a realistic visual representation of the equipment in which familiarization and corrective maintenance tasks are performed. From an instructor's station, faults are placed on the simulated equipment and the student's performance is monitored. The AN/SPS-49 radar courseware provides a high fidelity surface simulation, including simulated radar video, of the equipment operation which is sufficient to permit the accurate diagnosis and rectification of 23 simulated faults. Dubbed the Maintenance Procedures Trainer (MPT) and marketed as VISTA by LMC, eleven systems have been delivered to the Canadian Navy with more to follow. In addition, the US Navy is procuring VISTA for some of the equipment in the AEGIS and NSSN programs. The early systems have been in use for 3 years in the Canadian Navy. This paper will examine the project requirements, technical approach, system tradeoffs, the impact on training and the future direction of the program.

DRIVING SIMULATORS FOR TRUCKS AND BUSSES

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Within the last years, the use of high end driving simulators for basic and advanced training of truck and bus drivers in Germany became very common. In February 1997 the Federal Office of Defence Technology and Procurement awarded contracts for the manufacture and delivery of a training system for driving school training of truck drivers. In the beginning of 1999, the Berlin Traffic Agency (BVG) awarded a contract for a similar training system for bus and truck drivers training.

The purpose of the MOD project, was the design, development and delivery of a comprehensive set of training devices. This equipment comprises a driving simulator (three simulator cabins and one instructor station), a facility for computer based training including training lessons, adaptation kits for the connection of real driving school vehicles and a complex software, called „Intelligent Training Control", which manages the training means depending on their availability and the learning progress of the individual trainee. This system was field tested from April to December 1999.

Based on the system developed for the GE MOD, in the BVG project the additional requirements for a bus driving simulator have been specified and will be realised. Beside a bus specific drivers cabin requirements like inside rear mirror view with inside bus scenes, bus stop scenes, a new Berlin specific database and additional review functions have to be realised.

For both systems, the simulator consists of one instructor station and three driver stations. The instructor gets a status overview on "what happens" on in the different driver stations: the name of the trainees and names and levels of the training lessons are displayed on his screen. Furthermore the system informs him on the learning progress of the individual trainees and alarms him, when one of the drivers is in problems.

The instructor has the possibility to get detailed information of one driver station. In this case all information out of this cabin is presented to him: the front view, the image of the surveillance camera, the position of steering wheel, clutch, gear box, brake, throttle, position on the road map and so on. Whereas usually the pre-programmed lessons are conducted automatically, the instructor is able to overrule the system and introduce different entries interactively.

The driver station consists of the driver cabin, which is installed in a monocoque, also serving as a support construction for the spherical projection dome. The complete monocoque, including cabin, projectors and dome is moved by a 6-DOF electrical motion base, which is especially developed for this application, the so called Spider system.

USE OF OPERATIONAL DIAGNOSTIC SOFTWARE IN MAINTENANCE TRAINERS

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Re-use of operational software has long been a viable design consideration in operator trainers. In the simulation of computer-controlled subsystems characterized by complex functionality, frequent software changes, and the need for high functional fidelity, using operational software is often the best design alternative. Typically, fire control, electronic combat signal processing, navigation, or operator/machine interface software is used to support the simulation of ground vehicle or aircraft subsystems.

A subsystem that will continue to grow in complexity in the 21 st century is the on-board diagnostic software systems in ground combat vehicles. Ground combat vehicles that will make up the Army's Joint Vision 2010 force have an array of systems and vetronics that rivals the complexity of aircraft. Increasingly complex on-board diagnostic software is being developed to efficiently maintain these systems. It is expected that the diagnostic software will be modified frequently as vehicle subsystems are upgraded and automated diagnostic techniques are improved. Since the on-board diagnostic software will be the operator/maintainer's primary means of fault detection and isolation, a high degree of functional fidelity will be required to train the maintainer. These trends make it apparent that re-use of operational diagnostic software should be considered for maintenance trainers.

To investigate the feasibility of re-using on-board vehicle diagnostic software in a maintenance trainer, AAI and United Defense developed a proof-of-concept demonstration device for the U.S. Army's A3 Bradley Fighting Vehicle. The device was first demonstrated at the 1998 I/ITSEC Conference and used vehicle diagnostic software in a interactive courseware (ICW) environment. ICW led the maintainer through the operation of the diagnostic software to detect, isolate, and identify simulated faults that were inserted under lesson control.

The Bradley Maintenance Demonstrator showed that incorporating vehicle diagnostic software in a maintenance trainer is not only feasible, but also desirable for cost-effective training in the use of "real" diagnostic software. The proof-of-concept development effort also brought to light several technical issues that require consideration when contemplating the use of operational software in a procedure oriented-maintenance trainer. Two central issues are 1) the determination of the structural layer at which interfacing between operational and trainer software should take place and 2) the resolution of control between the two autonomous software systems. This paper reviews the advantages and disadvantages of using operational software in a maintenance training environment and discusses the issues raised during the development of the demonstrator.

SIMULATOR BASED TRAINING SYSTEM DESIGN - RECENT PROGRESS & LESSONS LEARNED WITH TRUCK DRIVING

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Experts assume that about 75% of all traffic accidents at sea, land and in the air have their reason in human unreliability. This paper describes a new simulator based training concept addressing the theoretical and practical imparting of psychologically determined causes of the unreliability of human acting. The simulator training shows the effects of repeated hindrances on the achievement of a goal through increasing stress and anger. They consist in a so called "fixation" of perception and action patterns in the way that the normal bandwidth and variability of actions is reduced. An important prerequisite for this kind of training is high performance simulators. This paper reports about development and testing of such a training program for professional truck drivers, including economical as well as anticipatory driving training.

SSAI

LINUX ON A PC: A VIABLE REAL-TIME GRAPHICS WORKSTATION

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High-end Unix-based computer systems have been the platform of choice for the past decade in real-time 3D Graphics intensive training and simulation systems. The relatively high initial investment and maintenance costs for these systems, coupled with their proprietary architecture, have prompted many developers and end-users in the training and simulation community to start searching for less costly alternatives, with comparable performance and a more open system architecture.

In many cases, top-of-the-line, multi-processor personal computers (PCs) running networked operating systems can meet the graphics-intensive needs of these training and simulation systems. The most widely used PC operating systems include Windows 95/98, Windows NT, and the relatively new Linux, which is rapidly gaining popularity among developers and end-users. Linux, which is a freeware operating system under the GNU licensing agreement, runs on a variety of computer architectures and has many similarities to Unix. This Unix-like quality makes transitioning a training or simulation application from the high-end workstation environment to a PC platform relatively straightforward, although not effortless.

This paper describes the porting of the Airborne Warning and Control System (AWACS) Modeling and Simulation (AMS) system, currently running on a set of networked Unix-based graphics workstations, to a PC platform utilizing Linux. The AMS is a U.S. Air Force multi-station training and simulation software system that provides ground-based Weapons Director (WD) mission crew training for the E-3 aircraft. The paper focuses on specific porting issues of the current system, such as graphics capabilities and performance under Linux, and also covers more general issues including ease of installation, availability of source files, and available commercial off-the-shelf (COTS) packages to support transition activities. Obstacles encountered during the porting effort are identified and discussed. The paper concludes with the lessons learned as a result of the transition of the software to the new platform and details the successes and failures of the effort.

DEVELOPING CREATIVE SOLUTIONS TO SIMULATOR DATABASE ENGINEERING PROBLEMS

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The 58th Special Operations Wing's Training Support Squadron, Mission Training Support Systems (MTSS) at Kirtland AFB, New Mexico provides initial/mission qualification and refresher training for Combat Search and Rescue and Special Operations Air Crew members. Training is conducted using several different media, including networked Weapon System Trainers. To provide visual realism in training, mission scenarios are fabricated in concert with a 3D visual environment, or visual database. In order to perform effective mission scenarios, however, extensive effort has been required to successfully integrate the dissimilar Visual Databases (VDBs) of these flight and mission simulators.

Because the initial fabrication of the VDBs required significant investment, the VDBs are an important training resource. The need for an ongoing VDB maintenance program has emerged as a result of technological advances, concurrency modifications, and changes in simulator training requirements. The MTSS team has learned that unless proactive processes for VDB maintenance is embedded in normal operational procedures, hardware and software upgrades, as well as networking compliance requirements tend to render a VDB less effective over time.

This paper discusses the reasons that VDB maintenance becomes necessary, and the lessons learned in dealing with VDB maintenance issues. The MTSS has taken its lessons over nine years of experience supporting VDBs on nine simulators, and specific examples of problems and associated resolution techniques are discussed.

INTEGRATING VOICE RECOGNITION SOFTWARE PROVIDING MORE EFFECTIVE TRAINING

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This paper will describe a Synthetic Solution for the 21 st Century by adapting COTS software to real world training requirements.

During analysis of measures of effectiveness, it became clear that the lack f a verbal interface was a detractor to the overall effectiveness of scenarios which normally require voice commands. With this in mind, the trainer for the "Engineering Officer of the Watch" (EOOW) was delivered in January, 1999 as a multimodal trainer intended to correspond to realistic scenarios as closely as possible. The EOOW trainer simulates the formal protocol an engineering officer must follow in communicating with engineering watch stations and the bridge during engineering causalities.

The EOOW trainer utilizes the IBM ViaVoice Gold voice recognition package to recognize the terminology of the formal protocol. In addition, it employs touch-screen technology to mimic the engineering control panels. The trainer was delivered using object oriented methods, allowing for increased flexibility and the interchangeability of system components. The architecture of the EOOW trainer is distributed, allowing for the simultaneous serving of multiple simulation scenarios.

Initial results indicate reduced cost and more effective training is being delivered. As voice recognition systems increase in popularity, the potential exists to develop diverse inter-service military training initiatives. It is one station in the Synthetic Theater of War; fielded now and ready to integrate with other stations.

DISTRIBUTED SIMULATION OPERATIONS: LESSONS LEARNED AND FUTURE CHALLENGES

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The right tools for the right phase of training is, and always will be the right approach for teaching. Exploitation of emerging technologies in tools and their implementation for distributed simulations are taking a revolutionary turn for conducting tasks from student training through Combat Mission Rehearsal/ Course of Action analysis. Budget cuts and active force reductions throughout DoD has everyone looking for answers that will maintain a trained and relevant force into the next millennium. Simulation has stepped up to fill the gaps and provide at least part of the solution. Traditional use of simulation for formal training will always have a place in the training of forces, however it has fallen short of providing the integrated and dynamic picture of warfare. We have learned great lessons from the pioneers of distributed simulation including Air Education and Training Command (AETC), the US Army, and our partners in industry. Our goal at the 19th Special Operations Squadron is to apply the lessons learned as a foundation for the future, and apply commercial technologies and systems that provide a bridge leading to a simulation architecture that is distributed, interactive, deployable, flexible, and cost effective. These systems will take the place many of the high cost proprietary systems. This paper focuses on the successes and failures thus far in the area of Distributed Simulation Operations, outlines our current architecture, and concludes with a vision for the future that provides integrated mission planning, analysis, preview, and rehearsal to forces around the world.

JEMP III AND THE JOINT TRAINING SYSTEM: SPEARHEADING TRAINING AND READINESS INTO THE MILLENNIUM

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For decades the United States Armed Forces have conducted event based training to prepare for combat. In that process of conducting event based training, both Service Component Commanders and Joint Force Commanders have had no way of truly determining how "ready" their forces were for combat. SORTS C-Ratings and a commander's subjective evaluation of his unit provided a fairly accurate look at sheer numbers and status of equipment maintenance in an organization, but provided no objective way of assessing a unit's true readiness for combat. In 1994 the CJCS initiated the Chairman's Readiness System and a concomitant move to Requirements Based Training. By making these sweeping changes, the CJCS could now make realistic assessments of the readiness and training state of his Forces, and target resources in needed areas.

Immediate results of the changes were the development of a four-phased Joint Training System and the Universal Joint Task List (UJTL). In 1995 the CJCS had a definitive system in place for the CINCs to determine actual joint training requirements, develop their Joint Training Plans (JTPs), execute the training, and finally, to assess the status of that training. But with no automation in place, and literally hundreds of joint training exercises scheduled each year, there did not seem to be a practical way to effect the true transition away from event based training.

The Joint Exercise Management Package (JEMP) III program provides the answer to that effective transition by automating the entire Joint Training System (JTS). This paper will provide a brief synopsis of the genesis of the JTM and JEMP; specific detail on the automation of the 4 phases of the JTS, and what that automation provides to the commander; iterative changes in overall system architecture based on valued input of the customer base; and finally a perspective on where the program is headed and its potential uses in other arenas such as acquisition, scenario generation, and component training.

PARTNERSHIP FOR PEACE SIMULATION NETWORK

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NATO initiated the Partnership for Peace in 1994 as an invitation to non-aligned nations to participate in a program to improve the operational interoperability between NATO and the Partners to support peacekeeping and humanitarian operations throughout Europe. In June of 1998 the U.S. Secretary of Defense outlined a vision for Partnership for Peace training and education. At the heart of his proposal was recognition of the need for Partners to graduate to higher levels of sophistication in the conduct of military exercises and cooperative defense education. An exercise simulation network was part of a triad of initiatives proposed by the Secretary. Called the Partnership for Peace Simulation Network, it is expected to enhance the PfP by: strengthening command and staff planning among partners and allies; improving interoperability through the conduct of distributed combined joint task force training; and improving staff procedures and enhancing multinational cooperation through remote-site command posts with multinational staffs.

The PfP Simulation Network demonstration, held in conjunction with the April 1999 50 th Anniversary NATO Summit in Washington, DC, was the first attempt to conduct a distributed Combined Joint Task Force computer-aided exercise utilizing facilities and personnel of several Partner and NATO nations. The structure of the demonstration indicates the complexity of this task. The Combined Joint Task Force commander was a British Air Marshal. The CJTF headquarters was at the Summit site in Washington. Modeling and simulation technical control and the maritime component command were located in Sweden. The land component command was headquartered in Hungary. The land forces included two brigade staffs, a Finnish brigade in Washington and a multinational brigade in The Hague, Netherlands. The air component command was located in Nieuw Milligen, Netherlands. The demonstration featured several key technologies and capabilities, including: distributed modeling and simulation for training; web-based information management; Video Teleconferencing and desktop audio and video; Joint Digital Library for distributed learning and collaborative planning; and a command and control system on personal computers.

The demonstration proved the concept and viability of a PfP Simulation Network and is the first milestone enroute to establishment of a U.S./Sweden-led, European simulation network involving allied and partner nations. Enroute to achieving IOC planning has begun to establish a permanent network, expand the PfP Information System (PIMS), and execute an ongoing series of exercises. The first of these will be Exercise Viking 99, a command post exercise to be conducted from Sweden during November and December of 1999.

FACTORS TO CONSIDER WHEN BUILDING SYNTHETIC ENVIRONMENTS WITH COORDINATED EW AND COMM THREATS

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Over the years, many threat environments have been built for use in large, single purpose institutional trainers or as part of system evaluation exercises. Most of these threat environments have included traditional EW threats (Radar and IFF emanations), and some have included threat network Communications (both data and voice), but few environments have been built that combine the EW and Comm threats in a way that the two work together to produce an environment that recreates what is seen and heard.

Now that training and evaluation exercises are becoming larger and incorporating all kinds of disparate, distributed simulations, there is a need to create an integrated EW and Comm threat environment where coordinated activity can be presented for warfighter training and system evaluation.

This paper addresses some of the issues involved in making such a combined threat environment using reactive EW and Communications networks elements. It illustrates the importance of having both Comms and EW threats working realistically together in an exercise so the warfighter is presented with an environment where the contributions of each kind of jamming asset is accounted for fairly.

As an example of the features constructive EW and Communications threat models should have in this kind of cooperative simulation environment, a simple GCI (Ground Control Interceptor) situation will be discussed. This case will be used to illustrate how disrupting the traditional EW (IFF and Radar emanations) and the traditional Comms Voice and Data links can have similar effects and how combining them provides models with both greater realism and wider applicability.

THE SQUAD SYNTHETIC ENVIRONMENT - A NEW VIRTUAL SIMULATION FACILITY FOR DISMOUNTED INFANTRY

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The U.S. Army is in the process of fielding a Squad Synthetic Environment (SSE) at the Land Warrior Testbed located at Fort Benning, Georgia. This state-of-the-art virtual simulation facility consists of nine Dismounted Infantry Simulators, ModSAF 5.0 including newly developed individual combatant simulation capabilities, and two Reconfigurable Ground Vehicle Simulators. The SSE represents the culmination of many years of investment by the government, industry and academia working together to achieve a unique virtual simulation environment aimed squarely at meeting the needs of the infantryman. The Dismounted Battle Space Battle Lab (DBBL) and the US Army Infantry Center (USAIC) at Fort Benning are the proponents for the SSE. It is envisioned that the SSE will be used to support DBBL and USAIC simulation needs across the entire simulation regime, from TEMO to ACR and R&D. In this paper we describe the SSE in some detail, postulate the role of virtual simulation within the modeling and simulation (M&S) domain, and then look to the future and provide our vision of how the SSE can be used to support the Army's M&S needs well into the 21st century.

SCENARIO CELLS FOR MILITARY TRAINING SYSTEMS

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The current U.S. Military maintains a high level of readiness to respond to global deployments, such as Desert Storm, with a significant military commitment for a short period of time. Future deployments may exceed the pool of available forces for a sufficient period of time to require pulling resources from the American population. In order to meet the needs of large, sustained deployments, there will be a need for training systems with far more capability to bring in non-soldiers and prepare them for battle. The widespread use of Commercial Off The Shelf (COTS) computers and integration technologies has collapsed the cost and schedule of nearly all forms of teaching and training. The same technologies are being applied to existing military training systems. This growing capability of COTS systems provides the potential to scale up, almost overnight, to meet the needs of an extended deployment. The time to start preparing software applications for the future needs is already here.

This paper outlines the needs of an expanded military training program and the promising technologies that can be used to meet the needs. The paper puts forward a concept for Scenario Training Centers where COTS technologies are applied to meet near term and extended training needs. Scenario Training Centers are facilities that contain training rooms (Cells) which host real time, interactive, immersive training methods. The cells are video walled rooms with 3-D virtual images of specific situations which immerse the trainee in a virtual experience of selected scenarios related to the training syllabi. Body-mounted sensors relate the student's position and posture to the sequence of operations he/she is to perform and his/her responses to battle conditions. An AI-based Scenario Program provides automated interactive instruction to the student relative to his handling of objects and responses to battle images around him. The scenario software is not hardware-dependent and can drive 'scenes' into evolving families of COTS projection systems as they evolve.

In the near-term, Scenario Cells may have their greatest value in reducing the potential for training casualties in safety-critical training. These include a wide range of hand-held and crew-served weapon operation and ordnance handling. Syllabi-driven scenarios can also enhance trainee survival on live exercises by teaching night navigation, hazard/ordinance recognition, and evacuation route familiarization. Scenarios that enhance survival in combat will also reduce casualties in peacetime theater operations such as mine clearing, hazardous materials (HAZMAT) recognition, and rapid nuclear/biological/chemical(NBC) recognition and reaction.

Immersive training can start saving money and lives with the current and near-term COTS solutions. As the promising three-dimensional projectors and hologram cell technologies for immersive environments come closer to reality, the software community can begin maturing the military syllabi and designing the dynamic systems that will meet the stressing demands of peacetime and crisis deployments in the future.

MODULAR ROLL-ON/ROLL-OFF DESIGN CONCEPT OF A ROTOR-CRAFT SIMULATION CENTER

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The topic of this paper is to present a short overview on the idea of the modular helicopter simulator concept and its implementation in the realization of 12 helicopter simulators for a simulation center of the German army aviation in Bückeburg.

A ROLL IN/ROLL OUT RECONFIGURABLE APPROACH FOR MULTIPLE AIRCRAFT TYPE OPERATIONAL FLIGHT TRAINERS

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Operational Flight Trainers (OFT) require a visual system to provide pilot trainees with out-the-window visual cues. Even though the cost of image generation systems has come down in recent years, the cost of a complete visual system with a state-of-the-art dome or collimated cross-cockpit visual display is a significant portion of the total cost of the training device. Using multiple cockpit configurations with a single visual display system can decrease the overall cost of multiple training devices and increase the efficiency of their use.

Under an Air Force contract, a Reconfigurable Operational Flight Trainer (ROFT) was recently developed for the 58th Special Operations Wing at Kirtland Air Force Base in Albuquerque, New Mexico. The design requirement was for a roll in/roll out trainer that would permit more than one device to alternately use the visual display system. The initial device procurement was for a single cockpit, representing a UH-1N helicopter mounted on a moveable platform. The platform contains an Instructor Operating Station (IOS) as well as all necessary equipment and electronics to drive the cockpit instruments and control loading systems. The device was designed to roll into a docked position where a wide-angle (180 x 60 degrees) collimated display system provides visual cueing. When in the docked visual position, the device only needs to be connected to external power and interfaced to the Image Generator to provide full fidelity OFT training. When moved from the docked position to a room corner position, the device is reconnected to external power and used as a stand-alone procedures trainer with high fidelity instrument training capability. In this position another ROFT device could be rolled into the visual docked position for simultaneous full OFT training.

This paper discusses the challenges involved in designing the trainer to fit in a dimensionally constrained room.

ANALYSIS OF DEPLOYED TRAINING REQUIREMENTS IN THE F/A-18 COMMUNITY

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Naval aviators are limited in their opportunities to practice critical mission skills while deployed for reasons that include fiscal, operational and safety constraints. Efforts have been initiated that specifically address simulation technology requirements associated with deployed training. These efforts contribute to the development of deployed training capability by providing simulated environments in which to practice and refresh critical skills. However, to focus simulation requirements, deployed training needs, in the form of missions, tasks, and skills, should be identified. The specific objective of this effort was to begin to delineate potential deployed training needs and approaches for F/A-18 pilots. A deployed training requirements survey was administered to 38 pilots from three squadrons aboard the USS Kitty Hawk representing carrier air wing 5 (CVW5). The results across the ratings and free response survey items were consistent in indicating a clear need for deployed training. Air-to-air, smart weapons, electronic warfare, and integration were the mission areas with tasks that received the highest ratings and rankings in terms of need for deployed training. In general, these tasks are not practiced on every mission, are critical to perform, and have a high skill decay index. These factors combine to make them prime candidates for deployed training. In terms of deployed training strategies identified by respondents, simulation was mentioned most frequently. Besides simulation, a variety of additional and complementary training approaches were mentioned including computer-based training, video demonstrations of effective performance, and an organic TACTS capability. Future work should consider the tradeoffs between these many alternatives.

HOW COTS TECHNICAL DEVELOPMENT AND PROGRAM MANAGEMENT CAN SURVIVE IN A MILITARY WORLD

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The Operations Room Team Trainer (ORTT), provides the Royal Canadian Navy with equipment and operations training in a medium-high fidelity, combat Canadian Patrol Frigate (CPF) environment.

The ORTT required a communications system able to support one hundred a and seventy operator input/output voice channels with some positions receiving up to 15 simultaneous voice streams. The system required reproduction of several complex communications panels. It also required simulation of the versatile SHips INternal COMmunications system (SHINCOM) along with panel logic functions for several other communications devices.

Cost and schedule imperatives led to a program plan which maximized COTS/NDI techniques to minimize project-specific deliverables. The entire system was created from a small set of sub-system modules allowing custom designs to proceed in parallel with volume production. Design review documents and "custom" SDRLS were submitted on time with minimal support costs. In addition, an innovative ATM-like cell communication structure was developed to transmit both voice and data between the panels and processing nodes of the system.

This paper discusses the technical challenges and requirements of the ORTT Communications Simulation Subsystem, developed by Advanced Simulation Technology under contract to Lockheed-Martin, Canada, and the strategy and techniques used to develop this subsystem within schedule and budget.

A COMPARATIVE REVIEW OF CUEING TECHNOLOGIES MOTION PLATFORMS OR MOTION SEATS?

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Motion cues are essential in simulation because research shows that driving – or flying – requires an instinctive connection between the human body and the mechanics of the vehicle. Good motion cues are essential if the trainee is to learn this connection correctly. It follows that poor quality motion systems actually have a negative training effect. It has often been argued that no motion at all is better – and cheaper - than bad motion.

Motion platforms have evolved from that for the Link Trainer to the high-performance 6 DOF mechanisms now used for flight training certification. But they are large, inefficient, noisy and expensive - and it is, in any case, impossible for some types of sustained acceleration to be simulated by motion platforms. Pressure pad motion seats ("g seats") were therefore developed to provide cues of sustained acceleration for high-performance military aircraft. But the original g seat design had a significant latency and this was not corrected, so the machines have generally fallen into disuse.

New types of all-electric motion systems have been developed to overcome the problems of the older motion base and motion seat technologies. Remarkable improvements in performance, reliability and value can now be achieved. Silent, non-pneumatic g seats may be constructed with near zero latency, allowing improvements of training quality in many different areas of application.

The enclosed-capsule simulator with a motion platform is the most appropriate design when a number of persons must be trained to act as a team in a moving vehicle - of any type. Nevertheless, there are limitations to the realism to which continuous vibration (e.g. helicopters) or frequent shocks (e.g. high speed boats) can be applied without causing real damage to the simulator! The seat motion cueing system is more appropriate when the simulator must be small, lightweight and use the minimum of electrical power – or where vibration and shock cues are vital to the learning process. Seat motion systems may be added to large enclosed capsule machines.

A moving platform simulator generally requires the visual system to be carried on the motion base, but this is impractical for an all-round view, such as that required for driver training or aerial combat. VR headsets have a distracting weight and inertia that makes them unsuitable for experienced trainees but in combination with a motion seat they provide a compact simulator system. For ground vehicles, moving only the cab in relation to the stationary screen is quite effective, but large lateral displacements should be provided. A seat motion cueing system works on a different principle and therefore has significant advantages in a "stationary displays" simulator.

DOMAIN REQUIREMENTS FOR CONSTRUCTIVE WARGAMES FOR COMMAND AND STAFF TRAINING AND C4I STIMULATION

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A small team of engineers and subject matter experts at Lockheed Martin Information Systems has recently completed a Domain Analysis focused on constructive simulations used in both command and staff training (CAST) systems and command, control, communication, computer, and intelligence (C4I) stimulation systems. The intent of the domain analysis was to collect typical requirements for such systems and identify a common set of requirements that could be used to drive the development of a framework and toolset to facilitate future development of systems in the domain. This paper describes the results of that domain analysis. Specifically, it highlights the effort to sufficiently abstract and level the requirements to define the constructive simulation framework and toolset and it identifies the areas in which the currently recognized requirements are weak or missing.

REQUIREMENTS AND IMPACT STUDY OF INCREASING TACTICAL ENVIRONMENT SIMULATIONS IN TRAINING DEVICES

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Weapon system training devices traditionally have high fidelity ownship and sensor models. However, due to the amount of tactical player definition required (intel data), the tactical environments used on these trainers are typically of low fidelity. In addition, the effort involved in creating and validating tactical models represents a huge investment on the part of the training community. It has been proposed that one solution is to use simulations from other communities (Test and Evaluation, Mission Planning, etc.) which already have numerous validated models and scenarios. In the Modeling and Simulation community there is also a goal to create a simulation environment that can be used by all communities, including training. In addition, realistic distributed training through the use of DIS/HLA will also impact the training device. This paper discusses the results of an investigation of the imposed requirements and impacts on the training device to accommodate this higher fidelity.

In order to increase the fidelity of the tactical environment simulation, the tactical combat simulation itself must meet certain requirements imposed by the training device. These requirements include real-time processing, reactivity, multi-spectral emission, and the ability to accommodate trainer specific players such as banner towing or bombing ranges. Other considerations must also be taken into account in order for the simulation to be a serious candidate and fit within the training budget constraints. These include such requirements as the ability to run on a low cost platform and ease of update and maintenance.

Increase in fidelity of the tactical environment will also have an impact on the requirements of the training device itself. Impacts on sensor models and the data now available, as well as the use of this data, must be analyzed. The capability of the image generating system (if one is used) must be assessed. This may require an upgrade or impose limitations on the scenario. Other issues include internal versus external models (missile fly out models running external to training device) and datalink modes with other trainers.

Answers to the issues raised above can identify the cost and advantages/disadvantages of increasing the fidelity of the tactical environment through leveraging off work currently performed in other communities. Several simulations from the test and evaluation community have been analyzed/modified for meeting the training device requirements. Several existing tactical trainers have been analyzed for an increase in tactical fidelity and the impact and changes required. This analysis clarified the impact that these required changes would have on each system and the level of effort needed.

The integration of a high fidelity tactical environment simulation is possible in today's training device. The problems and tradeoffs can be accounted for, albeit with changes required for both the simulation and training device. The advantage to the training device is an increase in ability for tactical training and mission rehearsal versus simply weapons system training. Advantages to the tactical environment model may also be realized if the changes made to accommodate training device requirements are folded back into the originating community.

SIMULATION BASED ACQUISITION: HOW DO WE MAKE IT WORK?

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Acquisition Reform is a DoD mandated procurement policy that attempts to deal with the growing complexity and cost of new government procurements. Simulation Based Acquisition (SBA) is the paradigm that must be adopted by both industry and government in order to make this reform successful. All current and future DoD programs will follow this methodology.

This paper addresses approaches that make the abstract concept of SBA useful and realizable. The need for modeling and simulation (M&S) in the SBA paradigm is discussed and related initiatives that support M&S in SBA such as the Simulation, Test and Evaluation Process (STEP), High Level Architecture (HLA), and Integrated Product and Process Development (IPPD) are brought into the discussion. The message is that there is a need to push the technology envelope; it is not good enough to stay current. The SBA community must innovate and lead: The community can't solve problems by using the same kind of thinking used when the problems were created.

An approach to the realization of an SBA architecture is introduced that suggests a spiral development process wherein development crawls before it walks. Using STEP, developers simulate, test and evaluate so that they learn what works and what doesn't work. The approach suggests an interface that makes it easy to define analyses that can be performed on the virtual product model for all phases of the product life cycle. For any given product the approach can be demonstrated and used on a new project in the near-term yet is expandable and extensible for growth to the far term. The approach uses web-based technology, Java user interfaces, and the Common Object Request Broker Architecture (CORBA) communication protocol. The approach can be used in a distributed architecture for collaborative development by integrated product teams.

THE USE OF SIMULATION AND MODELING FOR ACQUISITION, REQUIREMENTS, AND TRAINING (SMART) IN THE VIRTUAL COCKPIT OPTIMIZATION PROGRAM (VCOP)

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The Virtual Cockpit Optimization Program (VCOP) is providing an answer to the problem of information overload for pilots of modern military aircraft while reducing the cost of upgrading legacy aircraft. The concept of the virtual cockpit program is to provide the pilot with information such as situational awareness, sensor imagery, flight data, and battlefield information in a clear, non-confusing and intuitive manner, thus making the aircraft easier and safer to fly while also improving mission performance. The majority of the VCOP activity involves the integration of advanced technologies into a single system that represents a significant leap ahead in cockpit design philosophies. Rather than concentrating on the aircraft and how it can be retrofitted to meet the needs of the next generation warfighter, VCOP furnishes pilots with the necessary enhanced capabilities to perform their job more efficiently. VCOP is comprised of the following five independently developed technologies: Full color, high resolution, high brightness helmet-mounted display (HMD) that incorporates Virtual Retinal Display (VRD) technology; Three Dimensional (3D) audio; Speech recognition; Intelligent information management; and Crew-aided cognitive decision aides. These technologies will be integrated based upon the principles of Simulation and Modeling for Acquisition, Requirements, and Training (SMART), the application of Modeling and Simulation (M&S) techniques and technologies to the entire product development cycle of a system.

INTEGRATION OF OPTIMIZATION MODELING AND DISCRETE EVENT SIMULATION TO REDUCE COSTS AND IMPROVE PERFORMANCE OF DEFENSE SUPPLY CHAINS

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Reduced budgets and global mission requirements require that the military supply chain performs efficiently to support unit operations and training. Optimization modeling and discrete event simulation are two analytical tools that can help supply managers evaluate supply chain performance, compare alternatives, and quantify results. However, many supply and inventory mangers do not understand how these decision tools are applied to reduce supply chain cost and improve performance. This paper develops examples that demonstrate the use of these tools to analyze the supply chain of a critical part. Linear programming is applied as an optimization tool to develop a minimum cost supply plan for a system of three supply centers and ten users. Discrete event simulation is applied to analyze the impact of random stock delivery and usage on availability. The paper provides a starting point for inventory managers to analyze their current analytical methods and implement improvements.

CONSISTENCY AS A FIRST STEP IN MOVING TOWARD A COMMON SYNTHETIC NATURAL ENVIRONMENT STANDARD

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The models and simulations being incorporated into today's training systems are becoming more complicated and expansive at all levels from the individual warfighter through the field commander. Training systems will encompass a battlespace that includes all aspects of the natural environment encountered in space, air, land and at sea warfare. Traditionally, each simulation has developed it's own independent environmental representations, with little consideration of consistency across an entire federation. This paper presents an approach for developing a synthetic common natural environmental standard that can be applied across an entire federation. A common natural environment is defined as consisting of the databases and models that transform the databases to multiple levels of fidelity and resolution. The common environment is derived from the Synthetic Natural Environment Representation efforts which have been adopted by Maritime Virtual Environment Data Specification (MARVEDS) working group as our model for the development of a synthetic natural environment specification. We will show that to qualify as common, all federates must use the same underlying databases and must use the same set of models and algorithms to achieve any particular level of resolution. Implicitly, the models and algorithms used to transform from a higher resolution to a lower resolution must be consistent with physical constraints and the processing used by the tactical equipment. Efforts ongoing in the Battleforce Tactical Trainer (BFTT) and the Integrated Ship-Defense (ISD) programs will be used to illustrate the need for the common environmental standard

TOWARD A COMMON SYNTHETIC NATURAL ENVIRONMENT

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The High Level Architecture (HLA) and its predecessors have sought to provide a degree of technical interoperability by providing services permitting simulations to interface and exchange data. While providing communications between systems is a necessary precondition for interoperability, it is not sufficient to guarantee meaningful training, since disparate representations within the different systems frequently provide inconsistent and conflicting results. When simulations must interoperate with other simulations and with Command, Control, Communications, Computers, and Intelligence, Surveillance and Reconnaissance (C4ISR) and other systems, consistent and correlated results to environmental queries is essential to achieve consistent behaviors between Computer Generated Forces (CGF).

Today, vast resources are expended for each simulation in the development of highly specialized Synthetic Natural Environments (SNE). The result is a duplication of capabilities in similar but disparate representations complicating the interoperability problem. Warfighter Simulation (WARSIM) 2000 Operational Requirements Document (ORD) establishes a requirement to "interoperate" with C4ISR systems at Initial Operational Capability (IOC) and with Close Combat Tactical Trainer (CCTT) at Full Operational Capability (FOC). These ORD level requirements are vague and general requiring further definition.

The Mitre Corporation, in support of the C4ISR framework, has developed the Levels of Information Systems Interoperability (LISI) reference model for defining the required level of interoperability. Increasing levels of interoperability bring increased costs for the shared or common "core capabilities" due to increased complexity of the software and interfaces. This commonality also reduces cost for each participating system since less system specific software must be developed and maintained. The cost tradeoff associated with higher degrees of interoperability can be assessed to determine a quantitative Return on Investment (ROI). LISI provides a methodology to assess the qualitative effectiveness of higher degrees of commonality toward the objective of improved interoperability. This methodology is being assessed to refine the interoperability requirements for OneSAF and WARSIM SNE.

With WARSIM and OneSAF in development over the next 3-5 years and the integration of OneSAF to replace CCTT SAF planned, the opportunity exists to incrementally engineer a common framework for a composable multi-resolution SNE, if required. At STRICOM, the WARSIM/JSIMS SNE team is working closely with representatives from the Synthetic Theater of War (STOW) program to provide a seamlessly integrated representation of the land, sea, air, and space. This provides a path to consistent environmental responses supporting interoperability for these and other programs at reduced cost and with enhanced capabilities through resource pooling. STRICOM has begun laying the foundation for incremental advances toward this objective through development of a Terrain Common Data Model (TCDM) funded by STRICOM's Technology Base and through research studying a multi-resolution terrain representation funded by DARPA's Advanced Simulation Technology Thrust (ASTT) program.

AUTOMATED GENERATION OF 3D VISUAL SIMULATION DATABASES FOR MISSION REHEARSAL

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A wide variety of emerging visual simulation applications require automated methods for digitizing the real-world in 3D form. Examples include movie/film production, architectural visualization, Internet-based electronic commerce, game development, and virtual reality mission rehearsal for military and emergency services operations. The DoD in particular requires systems capable of acquiring entire urban areas in 3D form within hours, versus the months required using conventional modeling techniques. This paper describes a developmental system designed to address these needs by processing video imagery of an object or scene into 3D graphics models suitable for insertion into a wide variety of standard modeling and simulation tools.

In its final form, the system will consist of a motion imager equipped with a miniature instrument package containing GPS and inertial sensors. Signal processing and image processing algorithms will process this combination of imagery and positional data into a complete 3D model of the imaged scene, tagged with geodetic metadata. The system will be suitable for ad-hoc use with a commercial camcorder, or for automated data collection using unmanned aerial vehicle platforms. It will make maximum use of emerging NIMA standards for imagery and metadata to facilitate integration within any application requiring high-resolution urban terrain digitization.

In order to maximize commercial applicability, the core algorithms are designed to function as a software pipeline without instrument assist, using camcorder imagery. This configuration was demonstrated in the R&D Rodeo at I/ITSEC 98, and a refined version intended for commercial sale will be demonstrated at I/ITSEC 99. The current implementation effectively captures fully textured 3D models of individual buildings and similar cultural features. A key conclusion reached to date is demonstrating that fully automated 3D capture using only passive imaging techniques is feasible.

CHALLENGES AND SOLUTIONS IN DEVELOPING A DYNAMIC TERRAIN ENABLED PC-BASED SOFTWARE IMAGE GENERATOR

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Over the last several years there has been a growing requirement for Ground-based simulation training systems. As part of this requirement there is also a need for added realism within the simulation to provide, in real-time, the manipulation of a simulated terrain database in a physically realistic manner during an interactive simulation. Dynamic Terrain is not new to the Ground-based simulation community. However, current technologies require high-end computational platforms, are not real-time (30Hz), and are often cartoonish in appearance.

This paper will examine techniques to provide real-time dynamic terrain in a commercial-off-the-shelf (COTS) PC with commercially available graphic accelerator cards. The task of developing Dynamic Tessellation is challenging, especially on a PC-based system. Dynamic Tessellation provides the ability to deform terrain anywhere in the database in real time without the need for predefined deformable areas. Both Pre-Tessellation and Instantaneous-Tessellation approaches will be reviewed as well as the effects of soil dynamics and dynamic texture.

Dynamic Terrain is a requirement for realism for the maneuver forces in the Synthetic Environment. Specifically the application of dynamic terrain encompasses mine breaching, bomb damage, building damage, soil plowing and snow plowing. Specific applications of dynamic terrain are for the Grizzly Trainer, the Armored Vehicle Launched Mine-Clearing Line Charge (MICLIC), Track Width Mine Rollers and Explosive Standoff Minefield Breacher (ESMB).

As part of the results of this paper a PC-based Dynamic Terrain demonstration will be available as well as conclusions and recommendations to the methodologies employed.

TASK-BASED METRICS FOR THE EVALUATION OF TERRAIN INTEROPERABILITY

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Historically, computer generated forces (CGF) have been developed using the system-level approach. That is, they have been developed as a unit with the terrain they operate on and use for behavioral reasoning tightly coupled to the rest of the system. Over the last several years, the evident trend has been towards making various CGF systems interoperable. To do this, system developers and integrators have sought to use the same Terrain Databases (TDBs) and/or live with the inconsistencies that arise when linking different systems together.

This paper will present a set of grid, polygon and task-based metrics that addresses the perceived behavioral differences of CGF when operating in TDBs of differing fidelities (by fidelity, we mean how closely does the terrain match the real world) and formats. The metrics focus on atomic behavior tasks and those that are shared across other higher level behaviors, such as planning and following a route. From the quantifiable differences in the low-level tasks, we can quantify the effect of the underlying terrain representation on the higher level behaviors. The results provide new insight into terrain interoperability issues and their effects on CGF behaviors.

VIRTUAL TARGETS FOR TWENTY FIRST CENTURY SIMULATIONS

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Based on today's rate of technological growth, the computational advances of the 21st century will provide the capability to realistically simulate physics-based phenomena in real-time. Real-time simulation and visualization of weapon system performance, as well as interactions between those systems and various sensors, will become routine in the acquisition, test, and training environments. Using today's high-performance computational capabilities combined with advances in computational electromagnetics, near real-time synthetic aperture radar (SAR) and infrared scene generation techniques are being integrated into weapon system trainers and simulators. Future advances will force increasingly higher fidelity modeling for both the weapon system and its operational environment. The U.S. Army's Simulation Training and Instrumentation Command (STRICOM) is meeting tomorrow's simulation challenges today by developing virtual targets modeled at the highest possible fidelity, using proven, repeatable engineering processes. This computer-aided geometric exploitation process results in a physically-realistic virtual target which is suitable for synthetic signature prediction and validation across a wide spectrum of frequencies. This paper will address these multi-spectral target-modeling requirements and discuss the application of these virtual targets in simulation environments well into the next century.

INFRARED SENSOR SIMULATION

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This paper describes technical/mathematical solutions for simulating infra-red sensor effects. We have implemented our simulation usin a PC ruinng Windows NT and off-the-shelf image processing hardware and software. In particular, we describe the computacion of the dynamic characteristics of the actual sensor package within the constraints of hardware and software enviornment. These characteristics can include video polarity, gain, contrast enhancement, noise, blurring, AC coupling, sensor defects as well as video overlays (reticules/test patterns), and are applied to the post-processor phase. This paper describes the research and development into the infra-red post processor (IRPP) algorithms needed to support the sensor simulation. The system performs all of the following operations in real-time with a 30 Hz refresh cycle. The IRPP is modular and can be easily changed by configuration data.

DATABASE REQUIREMENTS FOR MULTI-SPECTRAL (OTW/IR/RADAR) SCENE SIMULATION

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Correlated, multi-spectral scene simulation requires the development of a Multi-Spectral Terrain Data Base (MTDB) to support spatially consistent Infrared (IR), Night Vision Goggles (NVG), and Radar scene simulation that existing Visible Out-The-Window (OTW) databases do not support. MTDB's must contain the elements necessary for accurate simulation at the spatial, spectral and temporal resolutions in the sensor bands of the Systems-Under-Test. In this paper, Photon Research Associates (PRA) analyzes the information requirements of high fidelity simulations designed to support instrument testing in the IR, Radar and NVG to arrive at a set of requirements for information content in an MTDB. The paper will explore the terrain phenomena that affect sensor performance and explore methodologies for incorporating these phenomena in geo-specific MTDB's that can be applied across the spectrum.

SSAI

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DESIGN FOR HIGH DIS PDU TRAFFIC RATES

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The United Kingdom (U.K.) Ministry of Defence is procuring a system, the U.K. Combined Arms Tactical Trainer (CATT), based upon the Close Combat Tactical Trainer system (CCTT) developed for the U.S. Army. U.K. CATT supports exercises that are approximately three times larger than CCTT in number of entities and CCTT Distributed Interactive Simulation (DIS) Protocol Data Unit (PDU) traffic rates. The U.K. CATT requirements include a capability to connect, via Wide Area Network (WAN), sites in the U.K. and Germany to support training two Battle Groups in combined exercises.

This paper reports the estimated U.K. CATT DIS PDU traffic based on analysis of traffic. It reports the effect of the CCTT multicast implementation. It also reports the estimating techniques used to project U.K. CATT traffic for Local Area Network (LAN) and WAN environments and the resulting host interrupt rates, which is a key performance driver.

Timeslotting, an innovative technique for bundling DIS PDUs without increasing latency, was developed to substantially reduce the peak number of interrupts on host processors. Variations of this approach are available for the LAN and WAN gateway environments.

CONSTRUCTION OF HLA COMPLIANT FEDERATES/FEDERATIONS FOR THE SPECIAL OPERATIONS FORCES

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The U.S. Special Operations Forces (SOF) have recognized the need and benefit of the DoD High Level Architecture (HLA), and have taken a proactive role in pursuing HLA Compliance for their Distributed Interactive Simulation (DIS) legacy devices. The SOF have teamed up with the U.S. Army Simulation Training and Instrumentation Command (STRICOM) and the Advanced Distributed Simulation Technology (ADST II) program to migrate these devices to HLA, and have begun paving the way to leverage this new technology to advance their distributed simulation capabilities.

This paper highlights the SOF migration strategy to HLA compliance for each of the following five SOF training devices: the AC-130U Navigator/Fire Control Officer Testbed, the MC-130E and MC-130H Combat Talon simulators, and the MH-47E and MH-60K Combat Mission Simulators. In addition, the migration strategy for other supporting federation components such as stealths, computer generated forces, simulated radios, etc. will also be presented. The paper also includes HLA implementation issues such as the use of middleware and gateways to achieve RTI connectivity, development of Simulation and Federation Object Models, and HLA compliance testing. Lessons learned with regard to federate development, as well as the construction of the SOF federation, will be presented.

ACHIEVING INTEROPERABILITY: A PERSPECTIVE FROM THE STRICOM FEDERATION

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The U.S. Army Simulation Training and Instrumentation Command (STRICOM) is involved with transitioning many simulations to the High Level Architecture (HLA). To coordinate efforts and share lessons-learned, several major STRICOM programs have joined together to create the STRICOM Federation. The STRICOM Federation will be comprised of federates representing a variety of real-time, platform-level training applications such as an Rotary Wing Aircraft (RWA) simulation, Close Combat Tactical Trainer (CCTT) manned module, CCTT Semi-automated Forces (SAF), and Modular SAF (ModSAF). Each of the participating federates provide an example legacy system migrating to the HLA. Using the Federation Development and Execution Process (FEDEP) model as a guide, the STRICOM Federation will integrate the respective federates and move toward achieving interoperability in an HLA federation execution. Commercial and government tools will be used to help achieve federation objectives. This paper will describe the lessons learned in the development of the STRICOM Federation. The application of tools and where they can best be used in the FEDEP process will also be evaluated.

Rodney Long is a Computer Engineer for the U.S. Army Simulation, Training, and Instrumentation Command. Mr. Long has been involved in the development of the Data Collection Tool, Federation Management Tool, the next generation RTI, Federation Test System, the migration of the RWA simulator to HLA, and several of the I/ITSEC DIS Interoperability Demonstrations. He holds a B.S.E in Computer Engineering from the University of South Carolina and has 11 years of experience in modeling and simulation for the training community.
Kevin Mullally holds a BS degree in Electrical Engineering from the University of Central Florida. Mr. Mullally has been involved in the simulation industry for over 6 years. His participation includes the design and development of the DIS Test Suite (DTS), a DIS compliance test tool, and the coordination of DIS compliance testing efforts for exercises performed at I/ITSEC 96 and I/ITSEC 97. As a Project Engineer for AcuSoft, Inc., Mr. Mullally is responsible for the development of the Federation Test System (FTS), an HLA federation testing tool. Mr. Mullally currently chairs the SISO-SIW Testing Forum.

AN ARCHITECTURE FOR CREATING SIMULATED OBJECT BEHAVIORS

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Much work has been done within the modeling and simulation community to aid in the rapid development of distributed simulations. Enabling tools and technologies such as the Common Object Request Broker Architecture (CORBA), Java, and the High Level Architecture (HLA) specifications have assisted tremendously to advance the state-of-the-art of modeling and simulation. These tools make it easier to develop distributed simulated objects within a simulated environment and to have the objects interact with one another.

Developing the ways in which these objects interact in a realistic way, or *behaviors*, is a difficult problem. Typically, objects are scripted with a nonreactive behavior or with a very simplistic reactive behavior due to the difficulty in the development and reuse of more complicated behavior. Any behaviors that are developed for a specific simulated object are typically 'simulation-specific,' require a simulation programmer to implement, and cannot be used across various simulations.

This paper describes an effort to develop the process and the architecture for creating *simulation-independent*, *reusable*, and *reactive* behaviors for simulated objects. Simulation independent behaviors are behaviors that can be interfaced with any simulated object in any simulation, independent of a specific simulation domain. Re-usable behaviors can be used multiple times once they are built. Reactive behaviors have the ability to sense and react to the simulated environment. This paper describes the trade-offs and issues encountered during development of the architecture and provides an overview of a prototype system being developed that examines implementing the architecture with current technologies, such as Java, Java-based expert systems, and HLA.

ASSESSING INTELLIGENT SOFTWARE AGENTS FOR TRAINING MARITIME PATROL AIRCRAFT CREWS

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Use of intelligent software agents to play the role of supporting personnel in simulations has the potential to reduce the requirement for support staff and increase the instructor's control of the simulation. The research presented here examines the suitability of intelligent software agents to aid training of individual crewmember skills and team skills. In this evaluation, human crews, intelligent agent crews, and mixed human-agent crews performed a simulated antisubmarine mission by a CP140 Aurora maritime patrol aircraft. Mission performance was recorded and crew communications were observed and rated to determine whether the intelligent software agents could perform individual crewmember functions and whether they could provide the interaction necessary for crew coordination training. The results indicate that (1) the intelligent software agents can perform individual crewmembers' functions adequately; and (2) the intelligent software agents did not interact in a way suitable for crew coordination training. The paper concludes with a discussion of the generalizability of the results and the growth potential of intelligent software agents in crew coordination training.

DISMOUNTED INFANTRY SEMI-AUTOMATED FORCES (DISAF) 2000

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The U.S. Army Simulation, Training and Instrumentation Command's (STRICOM) Synthetic Environment & Technology Management Division (SETMD) sponsors the Research and Development (R&D) project know as Dismounted Infantry SemiAutomated Forces (DISAF). DISAF is a Computer Generated Forces (CGF) application based on the ModSAF architecture. DISAF was developed to add dismounted infantry to the virtual battlefield in a realistic fashion. SAIC began developing DISAF as part of SETMD's Dismounted Warrior Network (DWN) program. The results of this effort have been integrated into the ModSAF V5.0 application.

Although the DI capabilities contained in ModSAF 5.0 are a realistic simulation of Individual Combatants (ICs) and have meet the requirements of DWN, enhancements for general IC simulation are required. An ongoing effort to enhance the current IC simulation capabilities of ModSAF 5.0 is underway. Areas to be improved include physical and mental models, weapon systems, open and urban terrain behaviors, and Multiple Elevation Surface (MES) modeling. DISAF will also be extended to support voice control of IC units. These improvements will be transferred to the simulation community though integration of code into the OneSAF Testbed Baseline (OTB).

This paper outlines the DISAF features that have been integrated into ModSAF 5.0. It also describes the DISAF enhancements currently under development and under consideration for future development. Finally, this paper summarizes current applications of this technology.

FLIGHT FIDELITY VALIDATION: MILITARY APPLICATIONS AND COMMERCIAL PRACTICES

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Flight simulators used for the training of flying skills must receive careful scrutiny regarding the fidelity of the flight dynamics simulation. If the goal of the training simulator is to improve pilot flying skills and eliminate bad habits, then relatively high fidelity standards must be imposed on the design and validation of the flight dynamics simulation. Lower standards may be suitable only if pilot flying skill training is not a primary goal, if only to ensure that the pilot's flying workload does not interfere with the primary training activities, such as sensor operation. Either way, training simulator requirements must express flight fidelity performance goals in explicit terms to ensure that the desired training capability will be achieved. The commonly accepted method for expressing flight fidelity performance requirements is to cite specific aircraft flight characteristics in terms of the tests and parameters obtained through established aircraft flight test practices. A trainer specification typically lists tolerance values to express how closely the simulation must match the aircraft flight test data. For USN/USMC fixed and rotary wing flight trainers, a body of knowledge and experience has built up over the last two decades on how to define and achieve high flight fidelity through the combined efforts of knowledgeable aeronautical engineers and flight test pilots and engineers from both contractor and government teams. As a result of this joint process, a set of tolerances for military flight trainers that is comprehensive and stringent (but achievable) has evolved within Naval Air Warfare Center (NAWC) to ensure that military pilot training needs are met.

The military acquisition community assesses parallel commercial practices in the quest of increased cost effectiveness, and trainer flight fidelity is no exception. Aircraft data requirements for airline transport aircraft are well documented and the Federal Aviation Administration (FAA) has established guidelines for a process to officially certify devices for commercial pilot training applications. Recent military trainer acquisition programs have applied commercial guidelines instead of the comprehensive NAWC tolerances. The result is that important military pilot training tasks, such as maneuvering flight and stall recovery, may not be trainable in the simulator. This paper will describe the differences between military flight fidelity requirements and commercial practices to show where they are equivalent and where they are not. In particular, the military pilot training tasks compromised by the use of FAA Advisory Circulars 120-40B and 120-63 will be addressed, with particular emphasis on fixed wing applications. The paper will suggest guidelines for blending the most appropriate parts of the FAA Advisory Circulars with the necessary parts of the NAWC military flight fidelity requirements.

REAL-TIME SYNCHRONIZATION AND MODIFICATION OF A BEHAVIORAL VEHICLE MODEL FOR DISTRIBUTED SIMULATION

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Distributed simulations have become valuable tools for individual and group training. A combination of live, virtual and constructive distributed simulations that is highly promising for greater realism in training at reduced costs, called embedded simulation, is being explored by the U. S. Army's Simulation, Training and Instrumentation Command (STRICOM) Inter-Vehicle Embedded Simulation Technology (INVEST) Science and Technology Objective (STO) program for use in combat vehicles. Among the many technical challenges to be overcome is that of providing a simulation environment in which live vehicles, manned vehicle simulators, and computer generated forces can interact with each other as well as with the battlefield environment in real-time over a geographically diverse, distributed network. The main problem is the high communications requirements imposed by the need to convey large amounts of data among the various players. The Vehicle Model Generation and Optimization for Embedded Simulation (VMGOES) project at the University of Central Florida is focusing on this aspect of the INVEST STO program. The approach is to use a behavioral vehicle model that is context-based to match the actions of the human-controlled entity on the battlefield. By observing the surrounding environment of the vehicle model's location in the simulation at each update time step, the model will determine what context it should be in and perform the actions that are appropriate for that context. This will allow the vehicle model to match the human-controlled entity's behavior for a longer period of time than is possible with only dead-reckoning updates, thus reducing the communications bandwidth required. However, discrepancies between the vehicle model and the human controlled entity will inevitably occur and these must be detected and resolved to allow the vehicle model to function efficiently. The portion of our model that addresses this need, the Difference Analysis Engine (DAE), will be resident on the human-controlled entity. It will be able to observe the actual vehicle's actions as well as the simulation environment and the vehicle model itself. It then must evaluate whether significant discrepancies exist. If they do, it will immediately take the action needed to synchronize the vehicle model with the actual entity. These corrections can involve a simple State Realignment to update the vehicle model's location, direction and speed; a forced vehicle model Context Shift to match the context of the human-controlled entity; a Model Correction to change the way the model itself responds; and, as a last resort, a Model Suspension to revert to standard dead-reckoning until the DAE can recognize what context the human-controlled vehicle actually is in. This paper will focus on those DAE functions and on how techniques, such as temporal template based reasoning, neural networks and genetic algorithms, are being used to accomplish those DAE functions.

ADVANTAGES OF BATTLEFIELD SIMULATION SYSTEMS IN MODERN COMBAT TRAINING

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In the face of global cuts in defense budgets, simulation based training has been recognized as a solution that retains competency while reducing training costs. New tasks for armed forces, new scenarios, multinational structures, and restrictions in both financial and personnel resources including those resulting from environmental considerations require new concepts and solutions in the areas of military training, exercises and planning. The resulting loss of the 'reality' in conventional live exercises due to restrictions in the availability of supporting military personnel andother limitations caused by reductions in training grounds must be compensated for as much as possible through synthetic environment and modern simulation technology. Therefore, computer-based simulations, as training tools for effective planning, have become increasingly important.

Modern simulation systems should not have only one application, but should be used for both training and education and planning and analysis. This is important in relation to cost effectiveness and common databases for such areas as mapping, terrain, vehicle characteristics and tactics. Interoperability and reuse of battlefield simulations require the development of simulation systems which take into consideration the HLA (High Level Architecture) This paper will present some experiences that Slovenian Armed Forces have recognized at the field of battlefield simulations and introduction of HLA concepts in the training of commanders and commander candidates, staff exercises and planning.

SSAI

MODELING AND SIMULATION COMPOSABILITY

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The term composability is most often used in conjunction with object-oriented software development. In this respect, composability is defined as "the ability to rapidly create or adapt powerful systems to respond quickly to new hardware and software capabilities, dynamically respond to mission requirements, system health/integrity, operating environment, and possibly reconfigure during execution, for example, to trade fault tolerance or security for performance". [1]

In contrast, the modeling and simulation (M&S) community views composability as an element in the process to achieve automated scenario and exercise generation. In the eyes of the M&S community, composability allows a simulation system user complete flexibility to cross M&S domains or to configure a system "on the fly" from models or pieces of a model.

This paper is written with the express purpose of bounding the concept of composability in modeling and simulation, both what it is and why it is desired. Design requirements are defined, as well as challenges to the process. The paper concludes with a discussion regarding composability limitations within modeling and simulation.

COMPOSABILITY AS AN ARCHITECTURE DRIVER

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There are two main issues that must be addressed when building a composable simulation system. The most obvious is identifying the functional granularity of the composition. The choice for granularity defines the modules of the systems and therefore their building blocks. Compatibility across the functional composition boundaries can best be thought of as syntactical consistency (e.g., when two systems can exchange the agreed upon data in a clear and un-ambiguous manner). The semantic granularity of the system, the second and initially often overlooked issue, is where things like thoughts, concepts, and level of interactions begin to separate the system components. These divisions go a step further to start to define groups of modules that "make sense" together. Even though all the components might be able to exchange data with each other, the key is to exchange meaningful information in a flexible and timely manner. It is this capability the leads to a truly composable system.

There are similar architecture-related discussions concerning the computational and communication model of the systems and the target languages to be used. In the ideal world, none of these other issues should affect the design of the system. In practice, however, these issues are often the overriding determinants. The implementation, communication, and computational models tend to limit the resource allocation available to the software components. These limitations feedback to the designers and further constrain the architecture.

This paper will examine composability from an architectural perspective with Computer Generated Forces (CGF) as the target domain. We discuss an inversion of the traditional approach of first bounding the problem by decomposing the documented requirements, designing an architecture based upon required model functionality, and then negotiating interfaces based on model algorithmic needs. While this approach has worked in the past, very often after the system is operational, a new model requirement is added to the system that causes a violation to architecture precepts. Over time, this has caused many a system to become bloated and brittle. Instead, we start by stepping back from any specific model algorithmic requirements. This allows us to develop a component architecture that characterizes the information flows between notional categories of system components and not the specific implementation nor the functionality of the modules of a component. Some of these information flows are time-critical and high bandwidth, while others are broadcast, low bandwidth, and not time-critical. By building a system that supports the necessary types of data flows between categories of modules, a generalized interconnection context is developed. Furthermore, since the various model components are based upon the data flows rather than specific algorithmic centric views, we can compose and extend them as needed by the specific system application.

VULNERABILITY/LETHALITY SIMULATION ENHANCEMENTS (VLSE)

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The VLSE Project is one of a number of projects initiated under the Live Fire Test and Training Program. The program is sponsored by the Live Fire Test & Evaluation Office, located within the OSD Directorate of Operational Test & Evaluation (DOT&E), and is being performed in partnership with the Naval Air Warfare Center Training Systems Division (NAWC TSD), the Army's Simulation, Training and Instrumentation Command (STRICOM), and the Air Force Agency for Modeling and Simulation (AFAMS). The common thread amongst the projects is to find ways to more closely integrate training and testing activities, including modeling, simulation, and shared use of data. The primary objective of VLSE is to develop and implement a methodology for more realistic (i.e., detailed) damage assessments in direct fire gunnery simulations through improved use of live fire test data and models. Specific objectives of this effort include:

· Use data and lessons learned from tank-on-tank degraded states initiatives in DSWARS and CASTFOREM to develop a conceptual degraded states approach to damage assessments in training simulations.

· Generate a degraded states demonstration model and integrate it with one or more virtual training systems used by the Army National Guard for tank gunnery training; and with a constructive simulation (i.e., SAF) to demonstrate and evaluate damage assessment representations via a degraded states approach.

OBJECT-ORIENTED DESIGN APPROACH FOR SIMULATED TACTICAL SIGHTS

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This paper describes a design approach to simulate tactical sights within simulators and to facilitate a slaved-sight capability where exercise observers at a Stealth station can observe sight views seen by simulator crews. The design approach exploits object-oriented techniques using Ada95 inheritance and focuses on reusable components shared among system simulators and stealth stations. The approach has benefits including reduced network communication, cost-effective development, and others.

The United Kingdom (UK) Ministry of Defence (MoD) has procured a system, the UK Combined Arms Tactical Trainer (CATT), similar to the Close Combat Tactical Trainer (CCTT), and having a similar slaved-sight requirement. The UK CATT system is different in that there are more simulators and sights than in the CCTT system and CATT has a different image generator (IG). These differences forced a change in approach to simulated sights in CATT. The basic concept for the CATT slaved-sight approach is that the stealth station has the necessary information to construct a slaved-sight view including cursor position, laser range readouts, etc., given the state of the sight. System components with sights that can be slaved need only send state change information to the stealth station and the stealth station constructs the sight view using its local knowledge of the sight definition and the state information. This paper describes the CCTT and CATT designs. For the CATT design, the paper describes the common reusable components, their use across the system, the slaved-sight protocol, overall design features, and benefits.

WHEN THE NEED FOR IMMEDIATE HUMAN FACTORS ANSWERS CONFLICTS WITH "YOU WANT IT DONE RIGHT?"

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In the human factors arena, the conflict between "we need answers now" and "you want it done right?" often results in trade-offs and, occasionally, heated discussions. This paper describes one such project in the context of a workload analysis conducted for a sophisticated training simulator under development. In response to a request to determine if workload will be within acceptable limits for various operators of the system, a MANPRINT team employed a stream-lined methodology in order to meet a rapidly approaching deadline. A computer modeling tool was used to help overcome the lack of a platform to obtain direct measures of workload for the operators. The use of computer modeling also helped to reduce the trade-offs between providing results quickly and providing quality, defensible results. The methodology employed enabled a quantitative comparison to a comparable existing training system. The results illuminated potential workload problems and alternatives to bring workload within acceptable limits. The methodology and results of the workload analysis are presented including how the computer modeling tool was integrated into the process. Discussion is provided on the limitations of the methodology and how it can be improved.

EVALUATION OF A COCKPIT CONCEPT TO VERIFY TRAINING NEEDS

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The two-seater combat aircraft that went into service with the German Airforce in 1981 and with the German Navy in 1982 was based on operational requirements and technical standards of the 70's and earlier. Changes in the operational goals forced requirements for improving, conserving, and adjusting performance capabilities and made various equipment necessary being added to the current system. During the realization of these modifications aspects of human-machine-interaction and crew coordination as well as revision and improvement of the obsolete training concept corresponding to actual training needs were largely neglected.

To work out actual training needs for the crews an analysis and evaluation of human-machine-interactions and crew coordination in the cockpit was carried out, including analysis of specific demands on crew members and task allocations between crew and machine resources depending on various typical airforce missions. Extensive experiments were conducted with simulated and real flights tailored for airforce missions. Demands on crew members in simulated flights were measured with questionnaires and rating scales SWORD and ZEIS, and in real flights with questionnaires and rating scales ZEIS and NASA-TLX/ZEIS combination.

Experimental results indicated a wide range of demands and workload on crew members. Recommendations for actual training needs were established to revise and improve the general training concept. Beside these aspects extensive recommendations were determined to reduce demands and workload, optimize crew members interaction, and ensure the required performance level.

COMPUTER MODELING IN FUNCTIONAL ALLOCATION

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The complexity of simulation systems has created a challenge for system designers in creating systems that are optimal for both machine and human performance. One of the most useful Human Factors analyses in creating an optimal simulation system is Functional Allocation. While several methodologies exist for Traditional Functional Allocation between humans and computers, many problems exist with current approaches. WARSIM 2000, a computer-based training simulation, has tackled the challenge using computer modeling tools. A new approach, Systematic Functional Allocation, was developed in response to problems identified with Traditional Functional Allocation. This paper outlines Traditional Functional Allocation and its associated problems, provides a general description of Systematic Functional Allocation and describes how the new approach was executed for WARSIM 2000. A sampling of computer models, as well as output reports are provided and discussed. Systematic Functional Allocation has assisted WARSIM Human Factors engineering in making critical design recommendations which have significantly impacted the system design. While this methodology was created specifically for WARSIM, it has potential for use by other simulation systems and domains.

AUTOMATED SELF-ADAPTIVE MULTI-MODAL USER INTERFACE (ASA MUI)

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This paper describes the development of a new technology which causes a human machine interface to best-fit itself to the individual user, to the environment, and to the transitory states of each. The automated self-adaptive multi-modal user interface (ASA MUI), is a method and an apparatus for developing and implementing the design of a user interface which maximizes the usable communications bandwidth between the individual user and the machine, allowing the machine to accept and interpret input from the human by a variety of simultaneous means and allowing the machine to communicate to the human by a variety of blended, multi-modal communications methods. The unique features of this method of designing and implementing a user interface are: (1) that the user interface tests each new user, develops a database of each user's cognitive styles, learning preferences, or individual traits which impact human machine interface; (2) that the user interface self-configures to fit the individual user, monitors the user's performance and physiological states, and automatically adapts itself to changes in the user's states; (3) that the user interface accepts simultaneous user inputs of different modes, and (4) that the user interface outputs both blended and parsed communications of information in different modes and by different media simultaneously or sequentially to ensure maximum human machine interactive performance. The author explains the need for and the further development and implementation of the automated, self-adaptive, multi-modal user interface technology, describes the development and testing of a concept demonstrator, and provides recommendations for application of the technology.

VISUALIZING SPATIAL RELATIONSHIPS: THE EFFECTS OF TWO-DIMENSIONAL, THREE-DIMENSIONAL AND VIRTUAL ENVIRONMENT TRAINING DISPLAYS

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For training purposes, there are a variety of means for presenting spatial information to support and augment mental modeling. These include alphanumeric parameter lists, schematic diagrams, plan views and maps, perspective views, and synthesized virtual environments. From a training perspective, we need to know whether a medium contributes significantly to optimizing training resources. It should be implemented in a training program only if it presents useful information with a minimum of distortion, ambiguity, or irrelevant and distracting data. This is particularly true when trainees are learning to construct mental models of spatial relationships from instruments which do not offer a direct or intuitive representation of the necessary information. Under these conditions, the choice of display parameters implemented in a training system will directly effect its utility for aiding in the development of spatial problem solving skills.

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DETERMINING MOTION CUING REQUIREMENTS FOR THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) DRIVER SIMULATOR

A determination was needed regarding whether or not to incorporate a motion base into the future Marine Corps Advanced Amphibious Assault Vehicle (AAAV) Driver Trainer, and if so, the degrees of freedom (DOF) required to produce an accurate simulation. A force motion base was proposed as an option in the Naval Air Warfare Center Training Systems Division (NAWCTSD) AAAV Front End Analyses and in an industry-generated Systems Functional Specification, however, rationale for the necessity of force motion was not available. The task of determining the necessity for force motion cuing and the DOF required was somewhat formidable because no actual operational vehicle presently exists and only limited models of the vehicle and the environments in which the vehicle will operate are currently available. The end decision to incorporate platform motion into the AAAV Driver Trainers was based on data supplied from a number of sources (e.g., training effectiveness and cost data, historical data such as the Army's experience with the M1/A1 tank, and subject matter expertise). As part of the decision process, it was necessary to use analytic methods to determine the DOF that would be required to meet AAAV driver training objectives.

A survey was developed by the Training Technology Development Branch at NAWCTSD to query members of the AAAV Fleet Project Team regarding the expected salience of motion cues in each of six DOF (i.e., longitudinal, lateral, vertical, roll, pitch, yaw) for specified tasks and environmental conditions. Five enlisted Marines, with considerable experience driving the predecessor Amphibious Assault Vehicle (AAV-7A1), used a 6-point Likert-type scale to rate the intensity of expected motion forces for each of 22 anticipated AAAV training tasks to be performed in both water (sea state 1) and land operations (various surfaces). Survey results indicated that motion forces are expected to be greatest in the longitudinal, vertical, pitch and yaw axes during performance of the specified tasks. A set of decision heuristics, developed for the U.S. Army by Sticha, Singer, Blacksten, Morrison, and Cross (1990), was applied to the survey results to formulate recommendations for motion cuing requirements. The methods used to determine motion requirements for the AAAV Driver Simulator can be applied to any ground vehicle or waterborne craft, and similar results can be expected. The results of the research conducted were not the only factors considered in determining the requirement for motion, but helped to reinforce many assumptions about the need for motion cuing.

SAFETY FOR LIVE-FIRE TRAINING SYSTEMS

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An important component of military training is training conducted with live ordnance. Safety – the protection of life and property – is a critical requirement of the systems that provide this training. As software solutions are applied to these systems, methods and processes are needed to ensure that the implemented software solutions perform as required in a safe manner. These systems include a number of types:

· Systems that are part of the weapons being fired or that are part of "smart" ordnance
· Systems that are part of vehicles on which the weapons are mounted
· Systems that are part of the Command, Control, Communications, Computers, and Intelligence (C4I)
being used in the scenario
· Systems that are involved with the training itself - controlling targets, providing simulated data to C4I
systems, etc.
· Systems that are external to the training itself and that monitor the training to ensure safety

This paper will discuss the safety issues associated with these types of systems, the safety issues associated with live-fire training systems, and the practices of designing and developing safe software systems. Included in this discussion will be the analysis of case studies presenting various training incidents and how these might have been prevented through proper application of software safety practices.

INTEGRATING HUMAN ENGINEERING REQUIREMENTS INTO THE EARLY SYSTEMS ENGINEERING PROCESS

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The authors present the proposed functionality of a Human Centered Design Advisor (currently under development) that will increase the extent to which human factors professionals are involved in the system design. The authors submit that the most effective way to convince systems engineers to include the Human Engineering Process in the Systems Engineering Process is to reference human factors issues contained in IEEE 1220-1998, because systems engineers consider this document a credible source. When systems engineers are developing specific requirements, the HCDA should recommend human factors oriented requirements from the systems engineering community as opposed to coming from the human factors community. Finally, as the design progresses, the HCDA will have sufficient knowledge of the design task at hand and can provide context-specific advice from the human factors community on how to fulfill the human factors requirements.

TEAM SKILLS ASSESSMENT: A TEST AND EVALUATION COMPONENT FOR EMERGING WEAPON SYSTEMS

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The purpose of this paper is to report on the development of a team performance measurement system capable of supporting the Army's recent initiatives for testing systems and doctrine in synthetic environments. One mechanism for evaluating emerging Army systems and doctrine is the Advanced Warfighting Experiment in which a synthetic theater of war (STOW) environment is created. STOW environments provide a key function in the test and evaluation (T&E) process, yet they pose challenges for effective team performance measurement, an important component for providing feedback to the development process. Challenges include lack of control of task content, requirement to capture performance in near real-time, and the use of multiple observers who must be kept cognizant of ground truth in a complex, dynamic environment so that they can legitimately assess team performance. To address the challenges outlined above, the TRACTs (Tactically Relevant Assessment of Combat Teams) performance measurement system was developed. TRACTs capitalizes on recent work performed by the Navy and Army in the area of team performance measurement. It captures both task-based and team-based performance and is implemented on a computer-based, hand-held data collection device. TRACTs was recently used to evaluate team and task performance during an assessment of employment concepts for the Crusader system. Crusader is a revolutionary weapon system which will be fielded by the Army in 2005. This paper addresses TRACTs design, TRACTs data obtained during the Crusader experiment, and discussions of how these data can be used to augment the T&E process.

SYNTHETIC ENVIRONMENTS DON'T HAVE TO BE DIGITAL

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Synthetic environments have typically been perceived as testing and training facilities that provide visual, digital information about the world surrounding a task. This paper explores a more comprehensive interpretation that involves utilizing perceptual cues appropriate for the task and is not dependent on digital presentation of the task environment. AFRL/HESR has developed a three-phased approach to testing that includes laboratory, synthetic, and field-testing. In this method, the synthetic environment is a transitional platform between pure laboratory evaluation and field-testing. Appropriate environments are determined through selection, isolation, categorization, validation and analysis of the elements in the system to determine their relationship and interaction. Critical elements are used in the synthetic environment to test task performance. Examples showing the effectiveness of appropriately designed, non-digital synthetic environments, as used in maintenance task environments, are reviewed. Tools or mechanisms used in building appropriate synthetic environments are examined and the benefits associated with these intermediary platforms are discussed.

AFTER ACTION REVIEW IN SYNTHETIC ENVIRONMENT BASED TRAINING SYSTEMS: A TRAINING SYSTEM NOT A TECHNOLOGY.

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Few Synthetic Environment (SE) based training systems have been designed from a clean sheet of paper. Most have evolved from technical demonstrators that had more than one design aim e.g. technical demonstrator, operational analysis tool and (or) training system. The need to adapt these systems to provide training has led to the provision of training feedback through After Action Review (AAR). In these systems AAR has largely been provided by add-on tools. In this approach AAR is typically seen as an isolated add-on to the training system and methodologically sound procedures for the use of AAR tools in the training process are not well developed.

A model is presented of the total training system showing how the provision of training feedback in SEs by AAR interacts with all stages of the training process. AAR has implications for every part of the training process including the selection and design of the exercise, the trainees training history, the standards to be achieved, measures to be used, and the focus of the training event. The traditional add on AAR package is also unpacked to examine the role of the analysis package, the selection of measures and the two way process in delivering the trainees feedback. The role of, and requirements for, AAR authoring systems and take home packages are also considered. The requirements for delivering successful AAR are analysed in terms of the message, its delivery and the nature of the audience.

The differences between military training and exercising are evaluated for lessons in the use of training feedback and an argument is made to move the training feedback to information that will facilitate behavioural change.

Finally, the training simulation analysis system EXACT (Exercise Analysis for Collective Training) that supports AAR in live, virtual and constructive training simulations is presented. EXACT is a PC based MOD/DERA developed system which includes behavioural performance data analysis along with traditional OA battle measures.

COCKPIT/CREW RESOURCE MANAGEMENT FOR SINGLE-SEAT FIGHTER PILOTS

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The goals of U.S. Air Force Cockpit/Crew Resource Management (CRM) training are to maximize operational effectiveness and combat capability and preserve personnel and material resources through a focus on aviation human factors. CRM training provides crewmembers with performance-enhancing knowledge and skills tailored to fit the unique characteristics of each primary mission and covers six core behaviors: Situational awareness, crew coordination/flight integrity, communication, risk management/decision making, task management, and mission planning/debrief. While CRM training appears to be readily accepted by Air Force aviators who fly multi-crew aircraft, including two-seat fighter aircraft, there are differences among single-seat fighter pilots in the perception of the applicability of CRM training in their environment. These perceptual variances are highlighted by the fact that single-seat fighter aircraft do not have "crews," but rather operate in "flights" of individual aircraft, each with a single pilot, to accomplish their mission through a mutually supporting effort. This research was undertaken to examine how F-16 fighter pilots viewed the Air Force's emphasis on CRM; the breadth and depth of CRM skills and behaviors; CRM's applicability to the "single-seat fighter community;" potential changes to CRM training; and the pilots' dominant learning styles. The purpose of this study was to determine the pilots' *attitudes*, prior to later examining their behaviors.

WOMEN'S LEARNING AND LEADERSHIP STYLES: IMPLICATIONS FOR AIRCREWS

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Accident data reveals that at least 80% of the world's airline accidents are attributable to human factors related to crew performance rather than technical failures. Ambiguity, assumptions, lack of communication, confusion, discrepancies - these have resulted in serious loss of life. Therefore, continual examination of the factors that affect aircrew teamwork is essential.

Increasing numbers of women in airline crews and the elimination of the combat exclusion for military women pilots necessitate greater emphasis on technical training for these newly emerging populations. Training programs need to address learning and leadership styles that do not conform to the traditional paradigms of the current male-oriented cockpit operational environment. Effective gender integration and crew teamwork are essential to flight safety.

The purpose of this study was to: (1) examine how women's learning and leadership styles differ from those of men, (2) determine barriers to gender integration and crew teamwork and (3) make recommendations for more effective crew training programs.

A literature review was conducted concerning women's learning and leadership styles and a series of 28 surveys and interviews of both men and women civilian and military pilots was completed. Results indicated that conceptions of command, leadership, effective communication, decision-making and shared authority differed in meaning between men and women. Tannen (1991) stated that men prefer debate-like situations in which they pursue knowledge by ritual opposition, while women like to share and learn by interacting in a collegial manner. According to Gilligan (1982), authoritative systems are more important to men in defining relationships than to women. Sitler (1998) contended that women value affiliation and acceptance more than men do. Case (1995) reported that women operate in a facilitative style and men operate in a directive style. Pilot interviews revealed perceptions that men and women in their roles as members of aircraft crews think and understand differently.

A quantitative and a qualitative analysis of the collected data were completed. The analyses suggested a number of recommendations regarding aircrew teamwork training.

USING APPLIED RESEARCH TO MEET AVIATION TEAM TRAINING REQUIREMENTS

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One challenge for applied training research is to effectively balance the need to deliver a product to meet real operational requirements with the need to conduct a sufficient level of science. Although achieving this goal is challenging, success stories do exist; unfortunately, few have been documented. This inhibits other communities from benefiting from the lessons learned. This paper documents an applied research effort and offers lessons learned from balancing science and operational necessity while meeting naval aviation's aircrew coordination training requirements.

In 1990, 60 - 80% of all accidents in naval aviation were due to human factors errors. In an effort to reduce those accidents attributable to poor aircrew coordination, an applied program of training research was conducted. In general, the research was organized into three areas. First, the research sought to answer the question "How can aircrew coordination be defined?" Research was conducted using analyses of naval aviation mishap data, interviews with naval aviators, and studies in both operational and laboratory settings. The result of the research was a set of competencies crucial for effective aircrew coordination performance. Second, the research emphasized answering the question, "How should we measure the construct?" Research was performed to design and test measures that permitted a systematic approach to assessing aircrew coordination performance. This research produced a number of measures that have been successfully used for training. Third, the ultimate goal was to address the question, "How should aircrew coordination be trained?" Research involving empirical and field investigations was performed and the result was strategies, methods, and tools that effectively supported aircrew coordination training.

In combination, the success of this applied training research resulted in the establishment of a methodology for the design, development, and evaluation of aircrew coordination training programs for naval aviation. The methodology was used as the basis to implement aircrew coordination training throughout the naval aviation community. This paper will discuss the: (1) operational need, (2) research effort, (3) operational transition, (4) lessons learned, and (5) future challenges.

COMPUTER-AIDED WORK SUPPORT

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Computer-aided performance support technologies continue to transition from providing enhanced training support to providing enhanced training and on-the-job work support. This ongoing transition is increasingly moving computer-based systems out of the traditional training classroom and onto the actual work site, with the inherent goal of providing just-in-time work support at the exact point of need, irrespective of work setting, location, or associated environmental conditions. It is suggested that this transition from training to on-the-job work support requires new thinking, new technologies, and new models of task performance. Just as learning models are used to guide training design, task-specific "work" models must be used to guide the design and development of computer-aided work support systems. In developing such models, it is imperative that human performance be viewed as consisting of both correct performance and incorrect performance or human error. As such, correct performance and human error are two sides of the same theoretical performance coin. After developing a task-based model of human performance, the paper focuses on analyzing various maintenance activities from a human performance perspective. Based on this initial understanding, it then describes a computer-aided work support system developed specifically to support an aviation-related maintenance activity. Particular attention is focused on describing design features that were built into the system to minimize the flip side of human performance or that of human error.

MEASURING THE IMPACT OF ADVANCED TECHNOLOGY ON MANNING COMBAT INFORMATION CENTERS

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In anticipation of shrinking budgets, the Navy has begun to examine technologies that will support a reduction in the manning requirements, and hence increase the affordability, of 21st century surface combatants. Because more work per warfighter is not viable, reduced manning implies an increased use of technologies that offset the increased workload that would otherwise be placed on future warfighters. Advanced human-computer interfaces and software-based intelligent agents have the potential to alleviate the workload associated with the use of current systems. If these advanced technologies are designed and applied correctly, future systems will allow cognitive resources to be focused on the task of accomplishing the mission rather than on the tasks of interacting with systems and synthesizing data.

However, with the introduction of these new technologies, a basic question arises as to whether the new systems actually support the decisions and task strategies necessary for mission success. It must not be assumed that a new system will support a reduced combat team simply because it uses advanced technologies. To address the question of systems effectiveness, this paper will describe a framework for evaluating the effectiveness of new systems, an experimental paradigm for collecting data, and the types of performance measurement that are needed to assess the impact of thse new technologies on human performance in a combat information center. Evaluating the impact of advanced technologies on system effectiveness and manning requirements is difficult, but critically important, and this paper will present a theoretically-based approach to this problem.

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HUMAN-CENTERED DEVELOPMENT FOR DISTRIBUTED MISSION TRAINING SYSTEMS

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In a recent book, Donald Norman describes how products developed from lists of user demands often fail when they are integrated into work environments. According to Norman, failures occur because actual customers for a product and their needs are often different from the focus groups that were interviewed during product development. Further, Norman states that the design process is often a linear sequence of operations that inhibits interactions among members of the team. He recommends that designs should emerge from a process of observing customers at work together with frequent prototype evaluations by users and the design team including managers, engineers, software specialists, technical writers, and behavioral scientists.

The Air Force Research Laboratory, Warfighter Training Research Division, has applied this human-centered development process to create a four-ship, F-16 simulation testbed. The testbed has been used in a series of Distributed Mission Training (DMT) exercises with pilots and air weapons controllers. The goal of these exercises has been to identify and document how DMT systems can be designed and used most effectively to enhance mission skills. The lab's design team has used these exercises to observe warfighters at work and identify significant training needs. During and after each training exercise, feedback is used to determine how to refine the scenarios, procedures, and testbed systems to support a training environment that complements current flying training requirements. Exercises have included RoadRunner 98 (a composite force exercise), an air-to-air training evaluation study, and flight lead upgrade training. Collected data are being used to determine DMT strengths and weaknesses and to identify the best training uses of DMT. These data are also providing a basis for a performance measurement system to assess the effectiveness of training in DMT.

MODELING INFORMATION OVERLOAD

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This paper reports the development of a mathematical model that can be used to simulate information over-load. A decision maker is posited, whose task it is to evaluate units of information arriving at random times. The decision maker forms an opinion, based on the (possibly inconsistent) indications of the considered information. This information may or may not be relevant to his or her task, and any unit might or might not accurately indicate the true situation. Determination that a unit of information is irrelevant takes a small amount of time; evaluation of relevant information takes longer. The elapsed time to a prescribed level of confidence provides a metric of decision maker efficiency. The subject's effectiveness depends on how frequently relevant information is presented and to what extent he or she is distracted by the accompanying irrelevant data. The model permits prediction of the optimal rate of presentation of relevant reports as well as analysis of the effects of distracting data on decision maker effectiveness.

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RE-ENGINEERING LEGACY SIMULATIONS FOR HLA COMPLIANCE

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Simulation proponents are driven to replace existing simulations as a result of several factors. These include obsolete and inefficient source code, maintenance costs to upgrade aging hardware, need for expanded capability, and the requirement to be compliant with the DoD mandated High Level Architecture (HLA). Good business practices argue against the wholesale replacement of simulations due to the enormous cost of developing entirely new systems. TRADOC, faced with the need to maintain a entity-level simulation despite increasing maintenance costs and limited expansion capability, reengineered the Janus simulation with a new architecture, re-hosted on personal computers, and modified to meet the HLA mandate. The reengineered simulation is known as HLA Warrior. The paper addresses the policy management decision process to modify and adapt simulations rather than replace them. Using Janus/HLA Warrior as a case study, the paper details a non-technical process for re-hosting a legacy simulation with modern technology, to include achieving HLA compliance. The paper also discusses in-house versus outsourced tasks, budget management considerations, and modern architecture capabilities.

MANEUVER COMBAT TRAINING CENTERS (MCTCS) INTERFACE CONTROL DOCUMENTATION (ICD) CONFIGURATION CONTROL PROCESS

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The purpose of the Interface Control Configuration Control Board is to manage the process of input of new items into the core instrumentation systems in such a manner as to ensure Operations and Sustainment of major combat training systems in a manner that meets the customers needs and the providers configuration control concerns. Areas of interest in the management process include: the concepts of electronic commerce for discrimination of meeting items, agendas, approval processes and control of documentation, the concept of multi command inclusion in the process, and the concept of consensus in making decisions for each of the combat training centers. Version control and publishing of all changes are maintained by a joint IPT initiative between the Contract O&S provider and the Logistics configuration control engineers. The documents and supporting information are maintained on the STRICOM (Government) WEB site for access by developers, sustainment personnel, user community and other commands/entities involved in maintenance of the training systems. Each of these areas and the process of maintaining them will be addressed in detail in the paper and subsequent presentation.

LogARMS: STRICOM's SOLUTION TO 21 ST CENTURY LOGISTICS MANAGEMENT CHALLENGES

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The U.S. Army Simulation, Training and Instrumentation Command (STRICOM) Life Cycle Project Directors (LCPDs) who manage military training systems face three concurrent mandates: 1) a governmental directive to operate within a paperless environment by 2002; 2) to optimize training system utilization; and 3) to effectively evaluate the current performance of life cycle contractors in the support of training systems. These obligations are not mutually exclusive, but are in fact synergistic.

STRICOM LCPDs need the capability to quickly view and analyze, at any point in time, logistics information of their training systems, including availability, utilization and cost drivers. This information can currently be effectively obtained, transmitted, and presented in electronic formats eliminating the need for hardcopy reports. In addition, improvements in and access to new technologies (including the World Wide Web) and the advent of more sophisticated analytical tools combine to offer solutions to both the paperless environment and the need for decision support information.

There is a large range of technical solutions to address these mandates. The objective of this paper is to describe a solution implemented by STRICOM that allows the LCPDs to manage their respective Training Aids, Devices, Simulators and Simulations (TADSS) programs. The solution, known as Logistics Acquisition and Readiness Management System (LogARMS), consists of business processes integrated with new technologies to meet a paperless logistics management environment.

The ubiquitous paper chase will still burden companies and organizations as they enter the 21st century. The move to a paperless environment will ease the burden, but will still require adaptation of new technologies and business processes. To mitigate this, technology trends must be understood in order to ensure they are value added and meet the overall business need.

LogARMS is designed to lead the STRICOM Logistics Directorate into the 21st Century with a paperless and consistent method of logistics management business and information analysis. LogARMS objectives include maintaining consistency and integrity of logistics data, providing access and multiple views for operational and decision support functionality, and providing a paperless environment for entering, evaluating and reporting logistics data. Attaining these objectives allows STRICOM to more efficiently manage its support programs, ultimately benefiting the soldier.

PREPARING FOR THE DIGITAL BATTLEFIELD
MODELLING TRAINING FOR C 4 I SYSTEMS

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Computers are improving in power, speed and affordability by an order of magnitude every five years. Thanks partly to parallel improvements in miniaturisation and ruggedization, the use of this speed and power in C 4 I systems on the battlefield seems set to increase dramatically in the next few years. In spite of received wisdom about children's familiarity with computers, there is no evidence of any equivalent improvement in the ability of recruits to operate these systems. If this lack of ability is not to become a limiting factor on the "Digitized Battlefield", an affordable, dependable and practical training programme for C 4 I systems is urgently needed.

Training for C 4 I systems inevitably involves extensive use of computers as training devices. The widespread use of Computer-Based Training (CBT) and Distributed Training (DT), possibly embedded in operational C 4 I systems, will be essential in future to combat the twin scourges of skill-fade and rapid version upgrades for large, highly distributed user populations. Synthetic Environments (SE), of varying degrees of abstraction, will need to be incorporated within most, if not all, stages of such training. But C 4 I systems, unlike weapon systems and vehicles, tend to be developed using Rapid Applications Development (RAD) techniques. The use of RAD means that "design freeze" may occur after roll-out or may actually never occur at all. The long lead-times usually associated with CBT, DT and SE design and production are inconsistent with such rapidly changing requirements. At the same time, the costs and risks associated with the development of CBT, DT and SE make some form of rapid yet rigorous justification process highly desirable.

Thanks largely to the emerging standardization of computer user interfaces, it is proposed that a generic model of C 4 I systems training is now feasible. By adopting a scaleable default training solution at the outset of any C 4 I project, a strategy of modifying such a model as the main project develops is likely to be more responsive than the current strategy of starting from "scratch". It should also provide a reasonable initial cost estimate for training, a feature missing from most current C 4 I system requirements. Such a model has the added advantage that best practice could be incorporated incrementally, refining it over time. In this way, much of the analysis and design process could be re-used, thereby becoming both faster and more efficient.

ESTABLISHING CRITERIA FOR A POST PROJECT EVALUATION MODEL FOR TRAINING NEEDS ANALYSIS

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The recent work undertaken to develop agreed tri-Service Training Needs Analysis (TNA) procedures, reported at I/ITSEC 98, concentrated primarily in aligning those procedures operable at the pre equipment delivery stages of the acquisition (procurement) cycle. PPE has tended to be regarded as a lower priority so far in the drive to ensure that initial training input to long term equipment acquisition projects could be established and implemented. The focus of the effort has tended to concentrate towards aspects of the Scoping Study, Operational Task Analysis, Training Gap Analysis and Training Options Analysis. Whilst the tri-Service TNA Guide for Equipment Procurement Projects makes detailed reference to Post Project Evaluation (PPE) and states broadly the issues that PPE should address, the process and mechanism by which this task might be undertaken has not been developed sufficiently to be articulated so far. It was agreed that each of the three Services would develop their own procedures and to this end, PPE for Army delivered training is addressed here.

This paper puts forward the criteria that need to be established for effective PPEs to be undertaken. It describes the requirement to evaluate training both in terms of the product, i.e., the training delivered in respect of the new equipment, and the process, i.e. the means by which the training delivery system is derived. It looks at the criteria of effectiveness and efficiency in training and makes reference to the concept of quality. A brief description of the organisational element superimposed on the criteria domain provides a basis for the construction of an influence model for PPE that might have application in the British Army in the future.

GLOBAL COMMAND AND CONTROL SYSTEM (GCCS) TRAINING MANAGEMENT PROCESS

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The Joint Staff published the Global Command and Control System (GCCS) Training CONOPs in Sept. 1997, setting the stage for the current GCCS Training Management Process. AF/XOCE, as the GCCS Single Service Training Manager (SSTM) developed this process to manage the multitude of training requirements generated by the Department of Defense's (DOD) premier command and control system. It supports users from all CINCs, Services, and DOD Agencies in multiple functional communities.

The GCCS Training management process aligns with the four phases of the Joint Training System; 1-Mission Capability Requirements, 2-Planning, 3-Execution, and 4-Assessment.

IMPROVING TRAINING SYSTEM ACQUISITION THROUGH PROCESS-BASED REQUIREMENTS ENGINEERING

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Developing software intensive systems, such as complex flight and mission training devices, within the Department of Defense (DoD), continues to be excessively costly and time consuming and resultantly unsuccessful in meeting users' training needs. A myriad of government sponsored studies have attempted to improve bleak success rates for delivering training systems within the confines of initial cost, schedule and performance thresholds. Such studies have identified the following areas: shortfalls in requirements management and a lack of disciplined processes, as being at the crux of DoD's acquisition woes.

Two significant contributors to these acquisition woes have been the ever changing Government contracting approaches and the fundamental lack of acknowledgement of a "requirements management problem." Historically, requirements have been inadequately defined and poorly understood prior to release of training system procurement solicitations. Consequently, training systems have been consistently (and predictably) over budget, behind schedule and lacking in performance.

This paper addresses the problem of paying lip-service to user requirements by focusing on specific acquisition initiatives that have been developed as part of the acquisition strategy for a major U.S. Marine Corps training system program. We have identified three specific acquisition initiatives that collectively address improving training system requirements management. These initiatives focus on improving the processes associated with systems (i.e., requirements) engineering. Our approach to optimal process utilization is based on a tailored application of the Software Engineering Institute's Capability Maturity Models for Software Development and Acquisition and the Systems Engineering Capability Maturity Model. The tailored application of these Capability Maturity Models will be based on a "continuous-view" approach. Our "continuous-view" approach advocates reengineering existing software development, acquisition and in Particular, requirements engineering processes so that they cover the key process areas of the Capability Maturity Models, while ensuring that requirements are appropriately addressed through process-based requirements engineering practices.

MULTI-DEVELOPER REQUIREMENTS ENGINEERING

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Requirements engineering standards and processes are inadequate in the simulation and training industry to support programs with multiple developers and training objectives. This paper explains how the Joint Simulation System (JSIMS) program corrected that inadequacy by defining and implementing a robust requirements engineering process that maintains a standard, program-wide traceability and test approach, flexible enough to allow multiple development agents, of which there are eight, to use different development processes and requirements management tools. A key to this organized and successful practice was to get common plans, definitions and agreements amongst the development partners.

This paper describes how the requirements engineering process evolved and provided many lessons learned as it grew and improved to support the challenges of a program with diverse requirements and development processes. The requirements engineering process began with a collaborative effort to analyze and consolidate 12 source documents of approximately 6,800 requirements, provided by the various individual development partners, and create a single, common, binding set of top-level, or "system", requirements. These system requirements became the bounding program scope that satisfied training objectives all partners agreed to develop and test against. The next step was to sequence the delivery of these requirements, or rather the capabilities that satisfied these requirements. The sequencing was divided into 5 separate, but common product delivery milestones. A sequencing challenge was that all the partners had dependencies on each other's products and/or deliveries that had to be supported and coordinated. Each development domain became responsible for their "portion" of the system requirements, and was challenged to derive the next level or two of requirements that specifically defined functions unique to their development efforts, yet still allowed for cross domain interactions. The requirements engineering team created a common trace and reporting format, using web technology, to allow users, developers and testers to see the mapping and satisfaction of all system requirements within and throughout all the development domains. It is applicable to any multi-developer, multi-user program.

21ST CENTURY VERIFICATION AND VALIDATION TECHNIQUES FOR SYNTHETIC TRAINING MODELS AND SIMULATIONS

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As computer technology emerges into the 21st Century, the education and training community has found itself depending heavily upon the use of recent advances to improve training realism and reduce costs. The use of high fidelity models and simulations (M&S) is having a profound effect on our ability to train soldiers and civilians alike under near-realistic conditions. Improved capabilities in visualization, virtual reality, artificial intelligence, and distributed simulation are providing opportunities never before envisioned by our leadership. These same improved capabilities are also introducing risk - validation of the credibility of these models and simulations under conditions that are not always verifiable or testable. After more than ten years of explosive growth in the application and use of M&S in all domains, there is still no uniform approach to establishing and quantifying their creditability through standardized verification and validation (V&V) techniques. More importantly, with the increased reliance on battlefield and campaign level simulations such as ModSAF by the training community, these become extremely difficult, if not impossible, to validate using traditional techniques. This paper will address the critical needs to improve our standards in the V&V of mission critical M&S and will introduce standard validation techniques that can be applied to battlefield-level models to include: face validation, trace validation, historical validation, multi-stage validation, and internal validation. Each technique will be discussed in terms of how to determine when that method should be used, to include selection criteria, strengths and weaknesses of the method, and examples. References are available upon request.

INCREASING ORGANIZATIONAL PRODUCTIVITY WITH ACTIVE KNOWLEDGE MANAGEMENT

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Organizations can no longer rely on individual performers to succeed. The demands of global competition, cost reduction, quality improvement, and employee shortages dictate increases in organizational productivity. Improvements in organizational productivity can be gained by better managing the knowledge needed to do business. In recent years, knowledge management has been identified as a critical tool for improving organizational productivity. Knowledge management could have a substantially greater impact on productivity if the search for knowledge were to be eliminated.

Active knowledge management is defined as the environment in which relevant knowledge is automatically presented to the knowledge worker without a request for such knowledge. Active knowledge management is a collection of tools to automatically search for knowledge, detect it, organize it in any format, and correlate it with the business context and the knowledge workers' needs. This paper presents a sample architecture for active knowledge management and its components, as well as a discussion of active knowledge management's benefits and risks.

PARADIGM CHANGES UNDER THE CONCEPT OF THE IPT UMBRELLA

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The primary training device acquisition activity, from procurement through life-cycle support, for Navy and Marine Corps training systems for more than five decades has been NAWCTSD. For the past 18 years, NAWCAD MFS has been providing flight simulation support to the RDT&E functions, and has provided flight trainer devices to the Navy and Marine Corps for more than 7 years.. As DoD budgets, and program funding grew smaller, these two agencies began viewing each other more and more as competitors for training system programs. Further, in some cases during the normal procurement process and execution of training device development contracts, a combative relationship developed between the Government representatives and the contractor development teams. The competitive relationship between TSD and MFS and the combative relationship between Government and industry did not benefit the organizations nor provide a better training device to the Fleet. A major emphasis with the development of the Integrated Product Team (IPT) concept, was the paradigm shift to build a team comprised of Government agencies and industry participants structured to better support the product and customer. The UH-1N Aircrew Procedures Trainer (APT) project, by embracing the IPT concepts, forged a partnership between NAWCAD, NAWCTSD, and industry. Working together, along with the sponsor, PMA-205, and the customers, PMA-276 and the Fleet Project Team (FPT), the UH-1N APT team is an example of this paradigm shift. Besides establishing a healthy, cooperative working relationship between Government agencies and industry, the UH-1N APT project broke other paradigms with respect to the procurement process of traditional flight trainers. By having a team that worked together, non-parochially, to solve the project problems, non-traditional solutions became apparent. An "out-of-the-box" mentality was not just accepted, but encouraged. This paper includes a general description of the UH-1N APT device (particularly the unique aspects of the device, a description of IPTs, and focuses on specific examples of the benefits of the IPT concept, and lessons learned. Finally, a summary of the benefits of cooperation and partnership in these times of shrinking budgets, rapid pace of technology, and increasing training requirements is included.

LESSONS LEARNED WHILE MOVING BETWEEN DIFFERENT TRAINING DELIVERY SYSTEMS

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As new delivery systems are being made available and affordable, there is a rush to import old data and training into new formats required for the new delivery system. Stand-up courses are being loaded onto web pages and computer-based instruction is being incorporated with electronic performance support. Change is occurring at a very fast pace. Organizations seeking to expand and update existing training materials into the newer delivery systems are presented with unexpected challenges.

Different training delivery systems have their own characteristics that prevent the materials from being easily converted from one format to another. This paper will describe the policies applied and lessons learned in converting traditional instructor-led materials to computer-based instruction. The paper will discuss issues addressed at each phase of the instructional systems design process and strategies for successful conversion. The following areas will be discussed:

- Misconceptions of conversion projects.
- Resolving issues that arise when moving from traditional training to technology-based delivery systems.
- Streamlining the design and development of converted instructional materials.

IMPLEMENTATION OF AVIATION INDUSTRY COMPUTER BASED TRAINING (CBT) GUIDELINES INTO NAVAL AVIATION MAINTENANCE CBT

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The integration of Computer Based Training (CBT) products, Commercial-Off-the-Shelf (COTS) software products, and training software applications, such as the Aviation Maintenance Training Continuum System Software Module (ASM), into a completely operational training system is complicated enough without the additional burden of having to integrate a unique Computer Managed Instruction (CMI) tool for each CBT product. When CMI tools work only with particular authoring systems, and CBT products are developed on multiple authoring systems, the task of integrating training system components becomes more complex. In addition, the role of system configuration management is intensified by the need to keep track of which CBT product will run with which CMI tool. To address this problem, the Aviation Industry CBT Committee (AICC) developed CMI and CBT "Guidelines and Recommendations" to promote the interoperability of CMI systems. In this context, interoperability means the ability of a given CMI system to manage CBT lessons from different origins and the ability for a given CBT lesson to exchange data with different CMI systems.

In the case of the Aviation Maintenance Training Continuum System (AMTCS) Program, over a period of eight years, multiple courseware vendors will be developing CBT for various aircraft platforms. Portability of courseware between training devices, maintenance of courseware, and collection and management of training data are some of the issues faced by the AMTCS Program. To alleviate these problems the Naval Aviation Maintenance Training community adopted the AICC guidelines for CMI and CBT products developed and deployed by the AMTCS Program. CBT products developed for the AMTCS Program are required to be compliant with AICC guidelines. CMI products used in AMTCS Training Devices (ATDs) also require compliance. This policy has allowed seamless integration of courseware with CMI into ATDs. The process of implementing AICC guidelines into the AMTCS Program occurred in four stages: Definition of Requirements, Implementation of Requirements, Verification of Compliance, and Formal Integration into ATDs. This paper describes the events involved in each stage of initial implementation of the guidelines. This paper also presents lessons learned along the implementation highway and perspectives on a broader implementation of AICC guidelines in the future of the AMTCS Program.

CONDUCTING SYSTEMS ACQUISITION WITH SIMULATIONS IN THE 21ST CENTURY

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As the new millennium approaches, a question begs to be answered; how can the modeling and simulation technologies developed over the past fifteen years be applied to provide synthetic solutions to reduce the cost of systems acquisition? In the past year the call for simulation based acquisition has continued to expand. The idea of using simulations to support acquisition is not new, novel, or revolutionary. Supporting acquisition with simulation is sensible but also low risk and therefore provides potentially only a minimal reduction in acquisition costs. The opportunity before the community today is to morph the paradigm of the simulation role from one of supporting to one of conducting acquisition. Conducting acquisitions using simulation brings forth a whole new range of issues. It also transforms a low risk approach to a higher risk with the potential for significant cost reduction. Development of thought leadership by the simulation and acquisition communities to address this opportunity is required as DoD moves into the 21st Century. The problem is very board and the issues are many. This paper focuses on the challenges of conducting test and evaluation through simulation for systems acquisition. The keystone issue here is to define a process which could evolve a simulation architecture that will be accepted as a tool for conducting portions of test and evaluation beyond merely providing a supporting role. The results of our efforts will be valuable to Program Managers (PM) during the Milestone II to III phase of their system's acquisition cycle. Our approach is based upon working through such a process of defining architecture and simulation specifications to support the operational test and evaluation program for PM Grizzly. As a result of our effort to develop this architecture a need arose to also define a structured methodology that would help us to arrive at a useable result. Through the process put forth in this paper we are confident we have developed a useful methodology that will permit PM Grizzly to conduct segments of the Grizzly operational test and evaluation in simulation. This structured methodology is generic enough that it is capable of supporting other acquisition projects as well.

HELPING SMART PROCUREMENT WORK - THE UK SYNTHETIC ENVIRONMENT BASED ACQUISITION PROGRAMME

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The Smart Procurement Initiative (SPI) is a fundamental part of the Strategic Defence Review (SDR) and aims to deliver the equipment needed by our armed forces when they need it, with the capability that they need and at a price that is affordable.

The new initiative clearly requires new tools and a new way of working to support it and the demonstrated maturity of Synthetic Environment 1 (SE) technology is such that the time is right for the application of SE techniques to procurement. In 1998 a joint MOD, DPA, DERA 2 and industry team was formed to investigate Synthetic Environment Based Acquisition (SeBA) with the objective of finding a common way of working using SEs to support the goals of the SPI and systems engineering. The results of the first phase of their work were demonstrated to the Under Secretary of State, Mr John Spellar MP, on 23 March 99 and received his endorsement.

SUPPORTING BRADLEY A3 ACQUISITION USING SIMULATION BASED TECHNOLOGY

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The Department of Defense (DoD) vision for Simulation Based Acquisition (SBA) is to have an acquisition process that is enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs.

The Army's Bradley Advanced Training System (BATS) is an evolutionary training system that has implemented some of the basic tenets of SBA. The system was initially developed as a training and development tool for the Bradley A3 program. Through partnering between PM Bradley, STRICOM, United Defense and the Bradley Infantry School, the BATS program has grown to an interactive, interoperable training system that provided initial operator training support for the Bradley A3 Limited User Tests. Additionally, the BATS will be used to support the Bradley A3 Initial Operator Test and Evaluation (IOT&E) testing this fall. These initial successes in the program have led to evolutionary changes in the BATS system development, moving from a Gunnery only training system to a multi-purpose role of Gunnery and Maneuver training.

This paper will discuss the application of Simulation and Modeling for Acquisition, Requirements and Training (SMART) tenets through the development and implementation of the BATS program and highlight issues that are currently being addressed with ongoing integration efforts. SMART is defined as the integrator of simulation tools and technologies across acquisition functions and program phases. This paper will also discuss the implications of using SMART for the acquisition of weapon systems and their training systems.

LINKING TRAINING READINESS TO RESOURCES AND WARFIGHTING REQUIRMENTS – CONCEPT TO REALITY

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A concept for linking Naval Aviation readiness to resources and warfighting requirements was presented in a paper at the 1997 I/ITSEC. The concept came to life in December 1998 with Version 1.0 prototype of the Naval Aviation Training Decision Support System (NATDSS).

The NATDSS prototype journey began in the Marine Corps in 1993 when the Director, Training and Education Division, Marine Corps Combat Development Command determined that allocating training resources needed to be directly related to mission accomplishment and training readiness. The project migrated to Naval Aviation and became known as NATDSS.

NATDSS is a modular, PC-based decision tool which uses embedded, government off-the-shelf (GOTS) and commercial off-the-shelf (COTS) software to structure the aviation training decision-making process. Standards are evaluated to determine current readiness, deficiencies and requirements; actions are considered to correct training deficiencies and requirements; and programs are ranked. Resources are then allocated, thus improving current training readiness. NATDSS is comprised of four linked modules. First, the Training Readiness Assessment Module, using GOTS software and existing data collected by aviation squadrons, determines training readiness based on training events completed in airplanes and simulators. Second, the Mission Assessment Module links the training events to Universal Joint Tasks, Naval Tactical Tasks and mission essential tasks to determine the impact of training on mission readiness. As part of the project, mission essential tasks are being developed for Naval Aviation Communities. Third, the Program Ranking Module ranks programs that were developed to correct deficiencies or implement new requirements. Analytical Hierarchical Process (AHP) COTS software is used to build and weight the criteria hierarchy structure. Programs competing for funds are linked to mission essential tasks to determine impacts on mission accomplishment. And fourth, the Resource Optimization Module uses linear programming algorithms to optimize program budgets and allow alternative discovery through "what-if" scenarios.

A STRATEGIC PLANNING FRAMEWORK FOR TRAINING THE SPACE TRAINING, EDUCATION, AND EXERCISE (STEDE) MISSION SUPPORT PLAN (MSP)

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Air Force Space Command (AFSPC) was faced with not enough training dollars and a poorly focused training planning infrastructure. To combat this, we fashioned a framework in which to engage the elements needed to build a space training, education, and exercise (STEDE) strategic plan. It encompassed organizational relationships between AFSPC, Air Education and Training Command (AETC), and Air Force Materiel Command (AFMC).

A key feature of this planning infrastructure is the task assessment template. This template is derived from AF Doctrine Document 2-4.3, Training and Education, and addresses STEDE support at the tactical, operational, and strategic levels of operations. The template decomposes training, education, and exercise tasks and subtasks at each of these levels of operations. It includes measures of effectiveness (MOEs) and performance (MOPs) by which to assess current STEDE support and to build roadmaps for the future. The task assessment template with its MOEs and MOPs is a tool by which to determine the appropriate level of STEDE support for each command task which derives from Air Force core competencies, enablers, planning areas, capabilities, and the mission-essential task list.

A beauty of this framework is that it assesses STEDE support not only for vertically decomposed command tasks but also for the horizontal, overarching tasks that are more prominent at the operational and strategic levels. It also captures the support vision and current assessment to AFSPC from other commands, most notably AETC.

This paper examines the structure of the STEDE template and its measures of effectiveness and performance. It then shows how this template has provided the essential foundation on which to build a command strategic plan which, in turn, is the basis for future year defense program (FYDP) budget submissions. The results are a structured, systematic, and well-defined training, education, and exercise plan which provides both vision and investment guidance for the next 25 years.

AUTOMATED MANAGEMENT OF SUBMARINE ON-BOARD TRAINING REQUIREMENTS

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Historically, the training time for shore-based courses provided at the Basic Enlisted Submarine School has been lengthy, and in recent years there has been a reduction in resources required to deliver this training. When sailors are engaged in shore-based training, they are not available on board the submarine to perform their duties. Also, data from the fleet indicated that much of the on-board training could be more effective (higher learning standards achieved) and efficient (less time required) than shore-based training. For these reasons, the U.S. Navy made a decision to provide more courses on board the submarine.

The U.S. Navy's Submarine On Board Training (SOBT) office manages the development and implementation of instructional courses and training products on behalf of the Submarine Force Type Commanders (COMSUBLANT and COMSUBPAC) for use on board submarine force commands. The shift from shore-based training to on-board training began about 10 years ago, and today, the SOBT office provides approximately 150 hours of Interactive Courseware (ICW), videotapes, printed workbooks, and computer-assisted instruction in the form of PowerPoint® slides. While the infusion of on-board training has been successful, it also created a management problem.

Short- and long-term management of the training requirements and course data was being tracked using many different non-standard processes, most with varying degrees of success. In early 1997, the Navy made a decision to develop a submarine force-wide tool to support the administration of training requirements and data. The tool is a Training Information Management System (TIMS).

TIMS provides information regarding training requirements (tied to training group), when the training will be conducted, the individuals who are required to attend the training, who leads and monitors the courses, the total number of training attendees, the length of the training, the media that makes up the training (both available and slated for delivery, such as emerging ICW programs), and the test data collected for training attendees. TIMS provides a system management function that allows a system administrator to update this information at any time.

TIMS is providing a flexibility that did not exist previously—most significantly, to allow training managers to automatically resequence training as schedules change. The instructors can also use TIMS to develop and edit tests from an automated question bank, view test data for each course, view and edit student data, and view question response data, all automatically.

FIXED PRICE AWARD FEES, MEETING TODAY'S AND TOMORROW'S CHALLENGES

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Department of Defense initiatives in recent years have focused on reinventing the way Government does business with industry. Coupled with these initiatives is the reality of declining budgets without declining requirements. In the arena of contractor maintenance and support of U. S. Army aviation simulators, these problems are compounded for the legacy systems fielded over the past twenty years. Budget constraints, and the promise of new technologically advanced systems being fielded in the coming years, has made sustainment and modernization funds very difficult to acquire. Aging of the legacy systems, with the persistent problems of obsolescence, has made the continued high system availability requirements a difficult challenge.

One method of dealing with this challenge, currently being tested by STRICOM, is the incentive use of Award Fees in conjunction with fixed price contracts. Although this marriage has been allowed by the FAR for some time, Award Fees are most commonly associated with cost plus contracts. Implemented properly, Award Fees have the promise of changing the basic relationship between the buyer and supplier, and greatly enhancing the partnering concept of conducting business. This paper will present an overview of how an Award Fee is being applied on a fixed price Life Cycle Contractor Support program, for aviation training systems. Selection of performance factors, evaluation criteria, determination of the level of award, impact on personnel, lessons learned and suggestions for application to other programs will be presented.

QUALITY CRITERIA FOR CONTRACTED OUT TRAINING NEEDS ANALYSES

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Training Needs Analysis (TNA) forms the core of the 'supporting case' required for the acquisition of military training equipments in the UK. The TNA process is defined in a tri-Service document which, on major projects, is supported by a number of other acquisition processes and procedures, briefly described in the paper.

Within any one financial year, the British Army has some 60 major TNA projects being undertaken. Each study may require two or more specialists working full time for 3-12 months. These factors mean that it is not feasible for the relatively small number of uniformed training support specialists to undertake all the TNAs themselves. Accordingly, most TNAs are contracted out to civilian consultants. A contracted out TNA may cost between £50-500K to support the acquisition of discrete training equipment systems costing up to £1B, hence it is important both that the TNA process is tailorable and that best business practice is followed – the main thrust of this paper.

In light of the above considerations, the orthodox business definitions of Quality Control (QC) and Quality Assurance (QA) are examined and interpreted in terms of UK military processes and procedures. Generic templates for different kinds of TNA project and different levels of military QC/QA activity are proposed and discussed in the context of the Smart Procurement and Public Private Partnership (PPP) initiatives. Examples of quality criteria for assessing commercial tenders for TNA and TNA deliverables are given. Finally, the long-term implications for achieving the Army's training requirement are discussed.

TECHNICAL AND BUSINESS CASES FOR OUTSOURCING TRAINING MANAGEMENT AT THE NATIONAL TRAINING CENTER

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The National Training Center (NTC) is the premier CONUS training site for the Army. Utilization of the facility involves some of the most advanced training technologies available together with the efforts of more than 3000 people. However, technology insertion at the NTC has seriously lagged while the evolving user requirements and costs for operation have risen. Although there are significant modernization programs in the wings, this is an ideal time to consider alternate business models for the NTC training systems management. This paper conducts an initial, high-level assessment of the outsourcing model for possible implementation at the NTC. Definitive statistics and costs were not available due to the widely spread accounting methods for NTC operations. Nevertheless, we attempted to baseline some data using interviews, STRICOM briefings and commonly accepted industry references. The discussion starts with a definition of outsourcing. The term has clear meaning in industry but is often confused with an "A-76" study/contract or "contracting out. We reasoned that if there were to be an outsourcing initiative for the NTC, a first step would be the identification of certain factors to be considered. There are numerous obvious metrics; beyond them, however, are a few subtle but potentially significant indicators that could guide an outsourcing decision. Accordingly, we carefully considered personnel issues, technology insertion and obsolescence issues, and forward costing.

In addition to the standard comparisons of personnel cost and numbers, we identified two factors for consideration: the personnel stability vs. time-to-train, and the specialization factor, which quantifies the specialized knowledge requirement for an assignment, vs. the knowledge level of the employee source. Technical factor analysis focused on the cost of obsolescence and the suitability of existing technology at the NTC to meet the needs of the users. These dynamics were measured across time, generating planning factors that are highly indicative of a need for business process review. Forward costing was established for technology-intensive, personnel-intensive, and balanced forward cost planning in light of empirical NTC contracting cycles. There is a clear indication in this metric that the 5 or more year contracting cycle does not work in the government's best interests in the areas of technology modernization.

The paper closes with a succinct discussion of findings, conclusions and recommendations.

DISTRIBUTED MISSION TRAINING: MODELING AND ANALYSIS OF TRAINING EFFECTIVENESS, COSTS AND RESOURCE ALLOCATIONS

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Distributed Mission Training (DMT) is a revolutionary training paradigm currently evolving at the Department of Defense, especially at the Air force. DMT combines virtual, live and constructive assets so that warfighters can train as they intend to fight. While the dimensions and complexity of modern warfare are expanding, the ability of the defense services to train forces in a realistic environment is being increasingly constrained. The primary constraints arise from limited resources for team skill training using actual equipment such as aircraft, safety limitations of live training events and security constraints due to operational conditions. Consequently, DMT is strongly emerging as an alternate but effective mode of team training in the defense services. In this research, we develop models and a spreadsheet decision support system to assess the training effectiveness, costs and resource allocations in DMT environments. The modeling framework performs parametric sensitivity analysis on (i) aircraft - DMT flying time tradeoffs, (ii) Training capacity analysis for joint aircraft - DMT training, and (iii) high level cost analysis of DMT configurations.

INFRARED SCENE PROJECTION, SYNTHETIC SOLUTION FOR TESTING AND TRAINING FLIR SYSTEMS

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Infrared (IR) scene projection (IRSP) is an innovative technology that will revolutionize and redefine test methodologies currently being used to test and evaluate Forward-Looking InfraRed (FLIR) and other thermal imagers. This emerging technology can easily be transferred and applied to meet the challenges of 21st century state-of-the-art training requirements. IR scene projector will provide realistic and repeatable operational-type test scenarios in a controlled synthetic environment tailored for IR reconnaissance, surveillance, and target acquisition sensors. These dynamic scenarios can contain numerous backgrounds, multiple targets, clutter, and countermeasures of interest to the testing and warfighter training community. This paper will include details of the Dynamic Infrared Scene Projector (DIRSP) and Mobile Infrared Scene Projector (MIRSP) major instrumentation developments. It will be shown that DIRSP and MIRSP are a unique application of modeling and simulation to real imaging IR sensor suites and systems. A brief description of related activities and how IR scene projector's domain of application can be expanded to include training will be presented. Additionally, this paper will discuss how IR scene projectors can serve as excellent tools to support simulation based acquisition (SBA) through the Simulation, Test and Evaluation Process known as STEP. IR scene projectors offer synthetic solutions, innovative and unique opportunity for cooperative development as well as leveraging opportunities for common FLIR test and training requirements.

JOINT INSTALLED SYSTEMS TEST FACILITY (JISTF) INFRARED SENSOR SIMULATION/ STIMULATION ENHANCEMENT: DYNAMIC VIRTUAL REALITY SIMULATION/STIMULATION TECHNOLOGIES FOR TEST, EVALUATION AND TRAINING

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The combination of declining investments in test assets and increasing test requirements dictates the coordinated and innovative development of modeling, simulation and emerging technologies to maximize use of scarce testing and training investment resources. This paper addresses the capabilities and development of the Joint Installed Systems Test Facility (JISTF) Infrared Sensor Stimulator (IRSS) system under the sponsorship of the Office of the Secretary of Defense (OSD) Central Test and Evaluation Program (CTEIP). IRSS is a modular cost-effective system that will be used to generate high fidelity Infrared (IR) scenes for stimulation of *installed* IR Electro-Optic (EO) sensors on aerospace platforms undergoing integrated developmental and operational testing. The IRSS will be capable of stimulating multiple types of sensors such as Forward looking Infrared (FLIR), Missile Warning Systems (MWS), Infrared Search and Track (IRST) and Missile Seekers.

The technical challenge for IRSS is that as a valid test tool, the spatial, spectral and temporal components of the IRSS computer-generated synthetic scenes should be of sufficient fidelity to produce sensor responses that are indistinguishable from the tested sensor's response to "real-world" conditions. This paper provides an overview of how the IRSS subsystems and functions meet the fidelity and data throughput challenge with emphasis on facility integration and dynamic real-time rendering of radiometrically correct simulation/stimulation. There is also discussion on the use of proven and emerging technology in IR modeling, scene generation, and scene projection components. There will be a summary of the risk reduction approach, design philosophy, and present status.

The IRSS is providing the basis for derivative systems for use by other DoD facilities and commercial organizations.

KEYWORDS: Installed Systems Testing, Infrared Sensors, Scene Simulation, Sensor Fusion, Interoperability, Electronic Combat Test Process, Infrared Scene Projection, Sensor Stimulation.

REALTIME FEEDBACK IN TRUCK DRIVER TRAINING

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In the beginnings of truck driving simulators, performance assessment of driving had to be done exclusively by the instructor, just by observing the trainee driving. From the instructors point of view this is not much different from sitting next to the driver in truck driving training on the road. In more sophisticated simulators [ThoDür 95] automated trainee performance assessment has been implemented and has so far relieved the instructors from lots of time consuming routine supervision work [Thoeni 97]. Such automated assessment is very valuable for the instructor, but it will not be sufficient to prevent the trainee from doing things wrong during training, it will tell him afterwards only. For certain tasks of maneuvering, where corrections by the driver are necessary to prevent undesired situations, the automated assessment of the trainee's actions shall generate immediate feedback. An example of such automated performance assessment in truck driver training with realtime feedback is presented here. Because in basic truck driver training the supervision of special maneuvering procedures is an essential and time consuming task, it shall be performed fully by an automated tutorial system. The driver receives, as feedback from the current path of the truck and/or trailer, driving instructions through an animated person. This person called SIGNAL MAN is placed in front of the simulated vehicle. According to the signs given by this animated person, the driver shall maneuver the truck and trailer over a given path to a predefined end position. This shall be possible forwards or backwards, with or without trailer, even when not looking into the rear view mirrors. This paper deals with the concept and the implementation of this virtual supervisor in the driving simulator. The possibilities and limits of this supervisor component for truck driver training are discussed and results are presented.

INFORMATION ASSURANCE: THE FORGOTTEN REQUIREMENT IN SIMULATION SYSTEMS

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In the course of satisfying requirements for functionality, user effectiveness, and performance, one category of requirements is regularly overlooked in the simulation community – the requirement for information assurance. Information assurance is usually considered as an afterthought, minimally addressed as a mandatory compliance requirement for system operation.

The next generation of simulation systems is being built on the premise of training using operational systems, with the same data, of the same resolution and fidelity, as the data used for operational missions. Consequently, what was once an unclassified simulation system may suddenly have classified network interfaces, or classified information as part of a previously unclassified simulation. Doctrine, tactics, and response times of units within a training exercise may or may not be classified. Distributed simulations, executing in federated networks of systems, may include coalition forces that may or may not be authorized access to live systems. The requirement for controlled information sharing among participants becomes much more prominent in this emerging environment.

Information assurance encompasses information availability, integrity, confidentiality, nonrepudiation, and authentication. It ensures that data is genuine, protected, and available where it is needed, when it is needed, and that it is used by authorized users for authorized operations. A primary feature of information assurance is system protection, detection, and restoration of systems to a known, secure state.

This paper presents a discussion of information assurance requirements in the context of simulation systems. The current and emerging requirements for information assurance are presented from both a regulatory and an implementation perspective. Implementation of Information Assurance in the HLA is addressed, as well as system certification and accreditation through the Defense Information Technology Systems Certification and Accreditation Process. The paper concludes with a discussion of the impact of information assurance on the system development process and system operations.

FREE SOFTWARE: OPEN SOURCE OR OPEN WOUND?

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From out of nowhere, the open-source movement is sweeping through the simulation and training industry with all the temperance of a locomotive. Take the Linux® kernel for example. It seemed only a year ago that Linux was considered no more than a hacker's toy or a graduate student's project. But today, Linux is endorsed by nearly every major computer hardware vendor and is found in a wide variety of applications from Web servers to full flight simulators (FFSs).

While known most for the Linux kernel, the open-source movement also includes many other software products, such as real-time operating systems, compilers, libraries, development tools and Web HTTP servers. In fact, the majority of HTTP servers on the Web today are powered by free software.

Yet there are still a lot more questions than answers when dealing with open-source software. As a vendor, how do I differentiate my product? As a software developer, how do I license my product and protect my intellectual property? As an end user, how do I service and maintain my systems? This paper looks beyond the hype and addresses these and other difficult questions that are associated with open source software.

In addition, also addresses both positive and negative common misconceptions about open source software. Finally, it gives examples of how open-source software is being used in simulation and training systems today and provides some lessons learned for those not yet following the open source herd.

NEXT WAVE SOFTWARE TECHNOLOGIES AND THEIR IMPACTS ON MODELING AND SIMULATION

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The recent introduction of Sun's Jini™ technology and its formative concept of spontaneous, "just-in-time" networks will dramatically and fundamentally change the way software is developed, deployed, and utilized since it represents the next logical step in the progression and fusion of distributed component architectures with network technology. The paper begins with a discussion of the problem domain and its characteristics and is followed by a description of the next wave software technologies and an assessment its impact on the development, synthesis, and collaboration of distributed models and simulations. The paper concludes with a representative simulation scenario in which the next wave technologies and enabling architecture can be practically applied.

AUTOMATED DECISION SUPPORT SYSTEMS ENABLED BY MODELS AND SIMULATIONS – A "LEAP-AHEAD" TECHNOLOGY RECOMMENDATION FOR THE US ARMY AFTER NEXT TIME FRAME (2020-2025)

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Keywords: Army After Next; Army XXI, Decision Support Systems; Force XXI; Information Dominance; Models and Simulations

This paper conducts an analysis of the future strategic environment, future guidance, evolving operational concepts and promising technologies and provides a Research and Development (R&D) investment recommendation that will benefit US forces during the Army After Next 2020 timeframe. Major survey documents include: The 1997 Quadrennial Defense Review, Report of the National Defense Panel – 1997, Joint Vision 2010, Army Vision 2010, the Army After Next Study Program, and the Department of Defense and Army Science and Technology Plans.

Based on this survey, the paper recommends the potential use of computer simulations to enhance tactical decision-making support (planning, preparation, and execution) during the AAN time frame. This recommendation, which espouses the requirement for a revolutionary new class of simulations, identifies an opportunity to provide a leap-ahead increase in combat effectiveness. The new class of simulation envisioned uses situational awareness information provided by digital Force XXI assets and provides tactical course of action recommendations in a predictive manner. The output from the new simulation provides efficient and effective recommendations concerning the use of all available assets in time and space. The author proposes that this new class of simulation should be the basis for a Course of Action Development System (COADS). While we assume information superiority will be provided by increase situational awareness, information dominance will not occur until we are able to use, most likely in an automated manner, the vast amount of information available. The proposed system will be capable of exploiting the vast amount of information available from our digital assets. In the words of the Army After Next Study Team, Force XXI mental agility will be effectively translated into physical agility.

Because this new class of simulations *develops* tactical courses of actions, instead of *analyzing* tactical courses of action (provided as user input) the size and complexity of the problem is difficult comprehend. Therefore, the technical risk associated with this recommendation is considered to be high. However, if we initiate an adequate research and development program now, we have 20 years in which to field an automated combat decision-support system for our Army After Next forces.

CHALLENGES OF LEADERSHIP IN THE 21ST CENTURY VIRTUAL ENVIRONMENT

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(1) In a world increasingly geared to Internet speeds, success is no longer simply a matter of getting there first, or being better equipped than the next fellow. The ability to quickly and effectively form, unite and lead teams who collaborate in a virtual environment based on "Web like" connections has become a major factor in getting the job done. Government agencies, commercial organizations and academic institutions are all experiencing the need for leaders who are as comfortable in leading at a distance as they are face to face. The virtual environment demands leaders who can, at a distance: (1) generate and refine ideas; (2) organize and integrate work; (3) sustain esprit; and manage boundaries.

(2) Virtual leadership is critical because organizations around the world are increasingly looking to virtual teams to make best use of their intellectual capital, to leverage scarce resources, to speed response times and to improve the caliber of their corporate decision making. Like some management fads of the past, virtual teams have been touted as a magic formula for solving organizational woes. They are not. But they can be enormously useful as a cost-effective way to improve innovation, productivity, speed-of-response and to institutionalize knowledge sharing as a core business practice.

Knowledge Management is a disciplined process for creating, capturing, sharing, and managing knowledge to meet mission objectives. This paper focuses on the empirical evidence of a direct relationship between knowledge sharing skills and the amount of time spent on reinventing the wheel and duplicating resources that exist out of sight, and are therefore out of mind. This paper presents (1) the simulations, and collaborative tools used in preparing leaders for challenges that await them in the next century, and (2) challenges and lessons learned in leading dispersed work teams.

A DISTRIBUTED VIRTUAL ENVIRONMENT FOR ARMY COMMAND AND CONTROL

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Army Command and Control facilities need the ability to function more effectively, with smaller staffs spread over a geographically dispersed area. As communications capability, visual simulation, and virtual reality (VR) have increased in capability and decreased in cost, these technologies have made distributed virtual reality applications attractive solutions for such problems.

This project is developing a set of tools which will allow distributed users to interact with existing Army command and control systems through a virtual environment. To provide immediate familiarity for existing users, the system will use a virtual model of a standard Tactical Operations Center (TOC) as the virtual environment. The system will support multiple users, allowing prototyping, evaluation, and training to be carried out in the virtual environment by users who are geographically distributed.

This paper describes the project requirements, technical approach, system tradeoffs, current accomplishments, and future direction of the project.

SEDRIS: THE KEY TO PROVIDING SYNTHETIC BATTLESPACE ENVIRONMENTS FOR THE 21 ST CENTURY

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The advent of networked, interoperable heterogeneous simulations has given the DoD an increased capability to support a broader range of training tasks, networked simulations and mission planning and rehearsal. This capability has created a demand for complex, integrated synthetic environments to provide the physical and environmental data for training systems and simulations. The process of producing a synthetic environment has become increasingly costly and time consuming as requirements have grown more complex. It is necessary to develop processes to reduce the development time for synthetic environments and to interchange and reuse environments between systems. The Army needs a common development process for synthetic environments to support requirements for visual and sensor displays, computer-generated forces, and digital and paper map generation at multiple resolutions. This process must also give the Army the capability to rapidly build these synthetic battlespace environments to enable home station and en route mission rehearsal for Strike Force, Special Operations and other contingency forces.

The Synthetic Environment Data Representation and interchange Specification (SEDRIS) project is an ongoing effort primarily sponsored by the Defense Modeling and Simulation Office (DMSO). The primary SEDRIS objective is to support an authoritative representation of the physical environment and to achieve loss-less and unambiguous representation and interchange of environmental data across the simulation community. The SEDRIS project has developed a data representation model, which encompasses all environmental domains – terrain, ocean, atmosphere and space, the companion application programmer interfaces, and a variety of tools and utilities. The U.S. Army Simulation, Training and Instrumentation Command (STRICOM) has provided engineering program management for the SEDRIS program and has been deeply involved in the prototyping efforts associated with the interchange of synthetic natural environments through SEDRIS.

As a result of these successful developmental and prototyping activities, STRICOM has included SEDRIS as a requirement for the generation of all future synthetic environment databases. SEDRIS is also incorporated within the internal database processes for both the Close Combat Tactical Trainer (CCTT) and the WARSIM programs. SEDRIS will provide the Army the capability to reuse costly synthetic environments and to reduce the timeline for producing integrated environment datasets. Future research and development efforts at STRICOM will focus on developing common processes to further reduce the cost and time required to generate synthetic battlespace environments, with SEDRIS as the key ingredient thoughout the production process.

INNOVATIVE SOFTWARE ARCHITECTURE FOR REAL-TIME IMAGE GENERATION

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Computer image generation has seen many changes over its relatively short lifetime. One of these has been the increasingly prominent role of software within image generators. From its original position as the invisible "front end" of classic dedicated image generators to today's role as an equal element in workstation-based systems, software has become an integral part of visual system selection and design. We see this trend continuing, with recently developed software technologies enabling a complete inversion. Soon powerful software will *be* the image generator with graphics hardware serving as an invisible "back end" beneath an intrinsic visual simulation platform.

Emerging software technologies provide the opportunity for a standard yet extensible real-time image generation platform, recasting software as the image generator that understands but does not rely on rapidly evolving hardware. This approach addresses many previously unsolved problems: it allows integrators to use features developed by others; it handles shortened hardware product cycles by providing customers with last minute (and even post-acceptance) flexibility in hardware selection and upgrades; it offers high-level portability and consistency where databases and features are shared across heterogeneous systems; and, it enables broad deployment of training systems across a range of hardware platforms, operating systems, and toolkit software, thereby increasing training impact and lowering costs.

ACHIEVING REAL-TIME VISUAL SIMULATION USING PC GRAPHICS TECHNOLOGY

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Recent advancements in PC 3D graphics accelerator technologies and CPU horsepower have produced compelling rendering platforms that are worthy of consideration for use in real-time simulation. The most prohibitive aspect of standard Commercial Off-The-Shelf (COTS) graphics accelerators is that they do not contain certain key features that are required for real-time simulation¾although many of these features may be simulated at the cost of significantly reduced fill rate.

This paper describes some of the challenges and solutions experienced in the development of real-time simulation features in a PC-based system. The critical features are enumerated and described. The exposure of these features through a Simulation Feature Library (SFL) programming interface is explained.

NEURAL NETWORK BASED SEMI-AUTOMATED FORCES: EXPERIMENTAL RESULTS

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In concert with the I/ITSEC '99 theme, Synthetic Solutions for the 21st Century, this paper explores a variety of ways in which neural networks, synthetic models of human cognition, can be used to improve performance in a distributed simulation exercise. Specifically, it examines the use of neural networks in semi-automated forces (SAF) systems as a means of reducing network bandwidth and processing requirements. To address the first performance measure, reduction of network bandwidth requirements, this research investigates the use of neural networks in lieu of the current, Newtonian, DIS dead-reckoning models. While this concept is demonstrated in a SAF system, it is extendible to other types of players (e.g., manned modules or live/embedded systems) in a distributed simulation. To address the second performance measure, reduction of processing requirements, this research considers the use of neural networks in lieu of SAF behavioral models. This concept does not extend beyond SAF systems.

This paper motivates the need for this research by reviewing how SAF systems work and why they are limited by bandwidth and processor constraints. It also introduces the theory behind the neural networks' architecture and training algorithms as well as the specifics of how the networks were developed for this investigation. Lastly, it illustrates how the networks were integrated with SAF software, defines the networks' performance measures, presents the results of the scenarios considered in this investigation, and offers directions for future work.

A UNIQUE COST EFFECTIVE ASSESSMENT TOOL FOR TRAINING ANALYSIS: ADVANCED MULTIMEDIA CONSENSUS TECHNIQUE (AMCT)

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Instructional Systems Design (ISD) is a systems approach that ensures an effective, cost efficient training solution by integrating the analysis, design, implementation and evaluation processes. Obtaining system information via surveys of Subject Matter Experts (SMEs) is a critical component of this process. The limited availability of the SMEs as well as the potential variability of survey responses often makes this form of data collection difficult. After completion of a survey process, an instructional analyst must examine the data and reach a consensus or justify the variations that may exist. Often, time and personnel constraints result in limited or conflicting data, causing difficulties reaching the required conclusions. In addition, short time frames and limited SME availability frequently prevent any follow up questioning. Because of these adverse circumstances and due to the criticality of data to the development of a training program, it is important that the data collection process be optimized.

As advances in technology result in more realistic and complex training systems, it is critical that a more efficient and accurate method of defining training requirements be developed. This paper introduces a unique, automated approach to optimizing the utilization of a SME knowledge base in a time and cost effective manner without sacrificing the integrity of the information collected. This method is currently implemented on a personal computer. Each SME's response is analyzed in real-time resulting in specific feedback to which the SME must further interact. Such tailored feedback demands the SME's undivided attention, preventing superficial replies to the survey. An improved user interface, provided through the use of verbal feedback in lieu of typewritten response, further increases the amount of data collected.

Using this automated interactive form of data collection addresses the deficiencies of the standard method of personal interviews and the typical paper-based and computer-based surveys. SMEs can provide data in a faster, more accurate and comprehensive manner, while providing the justification of their responses immediately. Using these data, an instructional analyst can continue the Instructional Systems Design process utilizing SME data that are complete and conclusive, without the need for extensive follow-up questioning. The database files generated by the survey software are available to the analyst for analysis and inclusion in the resulting training system analysis document.

THE NECESSITY AND DEVELOPMENT OF USER MODELING FOR FUTURE MODELING AND SIMULATION SYSTEMS

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As modeling and simulation (M&S) applications and real-world systems become increasingly complex and automated, more reliance will be placed upon the computer system to assist and direct the human operator in the operation, use, and manipulation of the computer system. The ability of a computer system to guide and direct a human operator is based upon three main factors: prior or input information, current situational information, and operator goal information. The prior or input information includes information related to the individual operator, the objectives of the operator and system, and models of previous operations similar to the current one. The current situational information includes current operator status, current objective status, current systems status, and current environmental conditions. Operator goal information includes a variety of knowledge about operator past, present, and future uses of the system or direction of tasking for system components within the current environment and other relevant environments.

To acquire and utilize even the bare minimum of the information included in the previously mentioned factors surpasses current M&S system abilities and computing resources. One promising technology for addressing this shortfall within the M&S community is the employment of the research results from the behavioral and cognitive modeling, or user modeling, community. The need for user modeling is pervasive in many M&S application areas and, although not overtly present in many of these M&S systems, user modeling is a critical portion of most modeling and simulation systems for new development, especially intelligent agents. To realize future capabilities for M&S systems, they must incorporate the ability to effectively model the user and user needs within the environment. This paper will address this requirement by motivating the need for and describing the benefits of user modeling employment within M&S applications.

SYNTHETIC VISION SOLUTIONS: OPERATIONAL SYSTEMS ASSIMILATION OF SIMULATION, LESSONS LEARNED AND CHALLENGES

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Synthetic Visual System prototypes are demonstrating great promise for increasing aircraft safety, increasing situational awareness and providing advanced steering cues in operational aircraft. Synthetic Vision enhancements are the beginning of a new wave of integration of simulation into operational equipment that will have far reaching benefits for both the operational and simulator communities. Specifically, the rapidity of the initial research imply that Synthetic Vision systems and associated simulation components may find near term application into operational systems. This paper presents representative examples of current synthetic vision research projects in the context of lessons learned and posits challenges to the simulation and operational communities to develop Synthetic Vision near term benefits for military and civilian systems.

An introductory Synthetic Vision example is given as a detailed description of how the authors plan to build a portable synthetic vision display with weather, terrain, and warning cues for vehicles by combining COTS components The discussion emphasizes the further advances made possible from baseline operational systems with GPS and Synthetic Vision. The advances detailed include the unique innovation of adding an advanced simulator as an active component of actual operational equipment. Such an approach is a revolutionary concept that has far reaching benefits. The addition of existing simulators as an additional active component to existing operational systems permits addition of advanced features at a fraction of the cost vs. conventional methods

A Synthetic Vision categorizations framework is suggested from basic low-cost "miss the mountain viewer" type applications to advanced multi-spectral displays for actual mission employment. A narrative description precedes the framework exploring characteristics, parameters and attributes associated with each category. An example of the framework applied to an existing Synthetic Vision prototype is presented. Three Synthetic Vision projects lessons learned, advantages, disadvantages and challenges are presented in summary format.

The challenges of a planned implementation a synthetic vision system on UAV ground control stations for NASA and USAF programs are discussed. The planned introduction of a four channel PC based reconfigurable simulator into UAV ground control stations are presented as an illustrative example. Planned benefits include:

- Geo-specific photo-textured Out-The-Window imagery on 4 channels to enhance situational awareness via a wider field of view and increase safety as weather obscuration nor night conditions will effect the correlated simulated visuals
- Super HUD -- Target Designators and Ground WayPoint Designators will appear over all four OTW screens
- Terrain Avoidance – A reconfigurable flight simulator adding F-16 HUD, Warnings and Instruments will be demonstrated as new capacities that the Predator Ground Control Stations can add.
- 360 degree high fidelity visibility option based upon a 6 channel PC-IG driving the USAF M2DART Display Synthetic Vision and the melding of simulators as functioning components of operational equipment are challenges for the 21st Century. This paper hopes to serve as a catalyst to advancing simulation into this new frontier.

CURRENT DEVELOPMENTS IN VISUAL DISPLAY TECHNOLOGY FOR FIGHTER TYPE SIMULATORS

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The trend in simulation systems for current fighter type aircraft is to employ increasing numbers of components that have been developed for commercial markets. The reason for this trend stems from two factors; the remarkable improvement in the performance of these system elements, and the relatively low cost of those elements.

This availability of low cost image generation equipment and high performance projectors has enabled the revival of a class of simulation display devices long thought too expensive to be put into general use in training simulations. These rear-projection display systems take a brute force approach to providing the pilot with high resolution imagery throughout his field of regard. This abundance of imagery, while a great improvement over systems with area of interest and/or reduced field of view images, has only recently become cost effective.

One new system that takes advantage of this progress is the SimuSphere developed by Raytheon. This display makes use of a well established dodecahedron structure. The modernization of the design has included advancements in all areas of the technology, from manufacturing to image generation. This paper will discuss a number of these improvements to the display hardware, including manufacturing tolerances and repeatability, mechanical and electronic alignment concerns, and ingress/egress issues. The benefits to the system wide solution resulting from image optimization and a compatible HUD design will also be detailed. Finally, any system that makes significant use of commercial components must have a clear upgrade path which benefits from their characteristically rapid evolution. Potential system enhancements resulting from improved projection and image generation products will also be explored.

RESOLUTION EVERYWHERE

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High-resolution wide-angle visual displays are finding increasing application outside the predominately military simulation community. The "cutting edge" of display technology and performance has, however, not advanced sufficiently to meet the new demands of published current and future military simulation training requirements. Consequently the highest performance display systems, although superior in resolution, field of view and luminance, have not reached the goal of "high resolution everywhere" that military flight training especially requires. This paper presents a novel display concept which will provide near eye-limiting resolution imagery over the full field of view.

REDUCING NETWORK BANDWIDTH IN COORDINATED TRAINING USING EMBEDDED SIMULATION

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The Inter-Vehicle Embedded Simulation Technology (INVEST) program is dedicated to providing onboard simulations in support of training exercises for tactical vehicles. For a particular vehicle, the onboard simulation is used to provide a virtual model of the vehicle, which then interacts with other virtual vehicles being used in the exercise. The Synchronized Player Model (SPM) part of the INVEST program was conceived to reduce the wireless communications bandwidth between the embedded simulations being used in a coordinated training exercise. This is done by synchronizing the simulations using a high-level behavior command interface, as opposed to the simple dead reckoning techniques currently used by most distributed simulations. In this paper, we describe the prototype development and preliminary results of a set of experiments where we use a software control algorithm for maintaining synchronization. We develop these experiments starting with a baseline system, consisting of the standard dead reckoning algorithms now in use, and compare our results against this known standard. The results indicate promising reductions in bandwidth requirements versus location fidelity errors for an SPM Phase 2 prototype testbed. Future work includes extending SPM synchronization concepts to unit level formation behaviors and the development of a prototype embedded SPM testbed suitable for the INVEST program.

PERSPECTIVES ON CONSTRAINT SATISFACTION IN THE MILITARY PLANNING DOMAIN

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Artificial Intelligence researchers have long used constraint satisfaction to solve a class of fairly well understood problems. During the past five years, TASC, along with SAIC in Burlington, MA and Logicon RDA, has worked to extend the applicability of this technique into the broader and less concrete domain of military planning. The results of this effort have included several software "command agent" systems, each capable of simulating the behavior of military commanders in the field, including mission planning and reaction. This paper presents an overview of the techniques employed and lessons learned in using this technology.

A general overview is given on the concepts involved in constraint satisfaction, including defining terms and standard solution techniques. Common applications of these techniques and the special problems presented by the military planning domain are then discussed. An example from the Army military domain Is used to illustrate these concepts.

The first software system developed using this technology is reviewed next. The architecture and development strategies of this serial, low-echelon Army planning engine, which culminated in the Synthetic Theater Of War (STOW) 97 Advanced Concepts Technology Demonstration, are discussed. Examination of ongoing research on improving the constraint satisfaction planning engine follows. Distributing reasoning over a network, modeling peer-to-peer and subordinate-to-superior collaboration, and abstraction of tasks are considered, as well as current applications.

SETHI Voice CGF control by speech-recognition/interpretation

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Today's development of virtual collective tactical trainers has spurred the need for human operators to interact in a user friendly manner with computer generated forces (CGF). This interaction is no longer limited to firing weapons, but also includes command and control relationships. For example company commanders under training have to control a high number of CGF subordinates. Furthermore role-players are often used to animate flanking or enemy units. These training configurations require means to rapidly command a large number of units with minimal additional workload.

THOMSON TRAINING & SIMULATION (TT&S) has designed and developed ground battlefield CGF software called SETHI (French acronym for Heterogeneous Interactive Tactical Environment Simulation) used in several operational systems. Today, SETHI units accept real-time orders given through a graphi-cal interface. Spoken natural language interface would be a quicker and easier way to give these orders. TT&S and Thomson-CSF Corporate Research Laboratory (LCR) are currently conducting experiments called SETHIVoice, aiming at controlling SETHI units with spoken operational orders. This technology involves speech recognition but also syntactic and semantic interpretation of utterances and mapping into CGF-executable commands. Albeit speech recognition is not a new technology, but the algorithms developed to understand natural language represent a breakthrough when compared to systems based on a sketchy and inflexible library of keywords.

SETHIVoice relies upon a LCR generic Natural Language Processing (NLP) platform called ThomSpeaker that aims at easing the development of new NLP applications. It is based on a multi-agent architecture and includes generic command and control grammar that facilitates the coding of linguistic resources, the recovery of speech recognition errors at the interpretation level, a linguistically based contextual interpretation, and the support of DIS communication protocol.

This paper will present the operational objectives of this experimentation, the issues raised, the solutions proposed, the first results that have been reached and how they may be further improved.

USE OF VIRTUAL PROTOTYPING TO CONVEY MAN-MACHINE INTERFACE CHARACTERISTICS

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Advances in computer technology are allowing more cost-effective approaches to be applied in the acquisition of large complex systems. Synthetic environments are being created that rely on modeling, simulation and advanced visualization to expedite design, manufacture, test and evaluation, etc., of new systems. A key element in this evolving acquisition climate is the *virtual prototype*. Use of a virtual prototype promotes communication among domain specialists by providing a common basis for discussion. While the benefits of virtual prototyping have been exploited in some communities, most notably by the aircraft and automotive industries, the wider use of virtual prototypes across the system acquisition cycle has been slow in coming.

An internal research and development project was undertaken in FY98 to examine the benefits of virtual prototyping as a vehicle for conveying desired interface characteristics for a man-machine system. The context for the project was the front panel of a SH-60B Seahawk helicopter (helo) cockpit. Although limited in scope, the project demonstrated both static and dynamic interactions with the cockpit prototype using immersive virtual reality (IVR) technology. The static phase involved real-time alteration of front panel gauge locations, using a data glove, and subsequent exchange of the location information over a local area network between separated computer-aided design and IVR facilities. The dynamic phase incorporated a high-resolution simulation, which allowed operators to "fly" the helo in the virtual cockpit while wearing a head-mounted display. The view in the synthetic flight environment provided out-of-window scenes and animated cockpit gauges. An HLA federation was created consisting of the helo, the mother ship and a surface ship threat. This paper describes the components of the helo cockpit virtual prototype environment. Issues and lessons learned in development and demonstration of the synthetic setting are discussed.

EVALUATION OF INTEGRATED AFV FIRE CONTROL AND DEFENCE CONCEPTS IN A VIRTUAL ENVIRONMENT

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The development and evaluation of new Armoured Fighting Vehicle (AFV) Fire Control System (FCS), Defensive Aids Suite (DAS), and Soldier-Machine Interface (SMI) technologies has traditionally been done on actual vehicles. However, the space and technological limitations of the host vehicle pose significant design constraints, the control of an actual turret and weapons impose costly qualification requirements, and field testing is costly and subject to the availability of suitable ranges and weather conditions. These constraints can be minimised by the use of a virtual environment.

The Advanced Land Fire Control System (ALFCS) is an R&D project to develop, integrate, and evaluate advanced FCS, DAS, and SMI technologies. Capabilities being developed and/or evaluated include automatic target detection and tracking, high-accuracy laser warning, automatic defence, data fusion and exploitation, multi-spectral counter-measures, advanced multi-function displays, reconfigurable controls, and simplified state and mode control.

To evaluate these and other AFV technologies, a virtual environment capable of hardware- and man-in-the-loop simulation was developed. This virtual environment, the Armoured Vehicle Test Bed (AVTB), includes a 6-DOF motion platform driven by sophisticated vehicle models, computer-generated visual and infrared imagery, accurate high-fidelity models of the environment, and models of the sensors and counter-measures required by the FCS and DAS. The entire system is re-configurable, facilitating investigations into alternate host vehicle configurations. The ALFCS project includes extensive design input and evaluation by current armoured vehicle crews. A four-build spiral development process is being used to integrate increasingly-complex systems.

The paper presents an overview of the technical details of the ALFCS virtual environment, and of the FCS, DAS, and SMI technologies under development and evaluation. It details the results of user and technical evaluations of the second of four builds of the project, including the integration of automatic target detection and a basic Defensive Aids Suite. The tactical use of a DAS is also discussed, including the results of a concurrent operational research study.

RETROFITTING C-5B AIRCREW TRAINERS WITH HLA-BASED NETWORKING: RESULTS AND LESSONS LEARNED

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As the benefits of distributed, multi-aircraft training become increasingly widespread, it becomes obvious that we cannot always take the course of building new aircrew trainers that are specifically designed to operate in a distributed, multi-ship environment. However, trainers designed five-to-15 years ago present unique challenges to operating in a distributed environment. The C-5B Distributed Mission Training (DMT) prototype project was put in place to integrate a High Level Architecture (HLA) interface to mid-1980's Air Mobility Command (AMC) C-5B aircrew trainers to allow the training of multi-ship missions. This program was AMC's first major venture into the DMT arena.

The ultimate objective was to gather as much information as possible on (1) issues associated with HLA, (2) limitations in the basic capabilities of the devices, as they applied to networked training, and (3) identification of potential high-risk or "challenge" areas for future DMT upgrade efforts. The results would provide the data necessary to intelligently manage the risks associated with future efforts to add DMT capability to other AMC trainers, and for planning additional capability upgrades to the C-5B trainers. This paper will identify and discuss the C-5B DMT modification effort, concentrating on the lessons learned and the issues affecting the addition of DMT capability to other legacy training devices.

AMC SIMULATOR AERODYNAMIC UPGRADE PROGRAM-MODULAR AERIAL REFUELING SIMULATION SYSTEM

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In response to training issues raised by the Air Mobility Command Director of Operations (AMC/DO), the Aeronautical Systems Center's Training System Product Group (ASC/YW), initiated a three phase program to improve the operational fidelity of AMC's large cargo and tanker simulators employed in ground training of aerial refueling (AR) tasks. Phase A, which is complete, identified deficiencies in existing training systems in the area of AR training as well as the aeronautical data necessary to upgrade the handling qualities of the aerial refueling simulations. Phase B, completed in June 1999, included an aerodynamic data collection and analysis program for the data requirements defined in Phase A. Phase C, currently underway, is incorporating upgrades to the large cargo and tanker simulators in several areas, including the aerial refueling aerodynamic simulations.

This paper describes results of a study for a Modular Aerial Refueling Simulation System (MARSS) to incorporate the previously collected AR data and improve the fidelity and utility of simulations used in ground training of AR skills. The MARSS is a common software module that provides sophisticated modeling of tanker and receiver aircraft dynamics, boom dynamics, and companion pilot and boom operator behavior. It is expected that the common MARSS will result in significant efficiencies and advantages over alternative methodologies for implementing the upgraded data and facilitate integration with developing Distributed Mission Training (DMT) initiatives.

The training device types that would use the MARSS are: the C-141B Air Refueling Part Task Trainer (ARPTT), C-5B Weapon System Trainer (WST), C-17A (WST), KC-10A WST, KC-135R Operational Flight Trainer (OFT), KC-135R Boom Operator Part Task Trainer (BOPTT), and the KC-10A Boom Operator Trainer (BOT). The MARSS module will reside on a stand-alone processor, which will interface with the respective host devices.

ANALYSIS OF A REAL-TIME HLA DISTRIBUTED MISSION TRAINING FEDERATION

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The first phase of the C-5 Distributed Mission Training (DMT) contract has been successfully developed and delivered to the Air Force Air Mobility Command. It has met its goal of using the High Level Architecture (HLA) to link two existing C-5 training simulators to demonstrate DMT technology capable of training missions such as formation airdrop and air refueling.

As this is one of the first real-time manned simulation programs delivered using HLA, it has been closely watched as a demonstrator of HLA's ability to serve the needs of training simulation and real-time simulation in general. To this end, the contract funded an effort to perform objective tests to analyze HLA Run-Time Infrastructure (RTI) performance in a real-time environment.

This paper provides a brief introduction to the C-5 DMT system architecture. The paper's major emphasis is on the purpose and results of the analysis tests that were performed on the C-5 DMT simulators. The four tests were network bandwidth utilization, RTI latency, processor utilization, and entity position error due to dead reckoning. All tests were run with a varying number of aircraft entities to show the trends that result from scaling to larger exercises. Use of the trends to predict system performance in larger DMT exercises is discussed. Also described is a means for simulating the effects of a long-haul network by injecting statistically random delay in the local area HLA network.

The overall conclusion from this project, verified by the analysis tests, is that real-time manned simulation is possible using the current HLA RTI under favorable conditions, but only for federations of up to 10's of entities. Federations of 100's or 1000's of entities will require an RTI with a corresponding order of magnitude increase in performance and capability.

ASSESSING THE BENEFITS OF IMPLEMENTING TACTICAL ENGAGEMENT SIMULATION CONCEPTS

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The workload of trainers for Army live force-on-force exercises is substantial due to the need to support the simulation of tactical systems and collect information on system employment. These activities pull trainers away from the important functions of coaching, mentoring, and presenting formal feedback. The fielding of new weapon and reconnaissance, surveillance, and target acquisition (RSTA) systems under force modernization will increase trainer exercise control and feedback (CAF) functions to a point that cannot be supported without interventions. Further, force modernization adds substantially to existing deficiencies in the intrinsic feedback needed to cue and guide performance during exercises and the extrinsic feedback needed to identify corrective actions for future exercises. Advances in tactical engagement simulation (TES) and instrumentation are the primary tools for reducing trainer workloads and addressing gaps in feedback, and the Army needs to know which concepts for new TES and instrumentation systems offer the greatest benefits. The goal of this project was to develop and apply an online database for assessing benefits of new TES and instrumentation concepts. This goal was addressed in three phases. First, we defined the set of trainer CAF functions and feedback gaps by examining 155 new and emerging weapon and RSTA systems. We identified 228 trainer CAF functions and 96 feedback deficiencies, with many of the functions and deficiencies applying to multiple tactical systems. Second, we developed information that could be used to weigh the value of addressing a specific CAF function or deficiency. We weighted CAF functions according to their tendency to distract trainers from coaching and mentoring responsibilities. We weighted trainer CAF functions and gaps in feedback according to the number of tactical systems to which the function or deficiency applied and the nearness of the tactical systems to their fielding dates. Third, we tried out the database by defining and assessing the value of 15 high level TES/instrumentation concepts. Collectively, the top five concepts eliminate 59 percent of the CAF functions and 75 percent of the feedback deficiencies.

TECHNOLOGICAL CHALLENGES FOR GEOMETRIC PAIRING FOR THE DISMOUNTED SOLDIER

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Since the early 1980s, the U.S. Army has conducted force-on-force Tactical Engagement Simulation (TES) exercises using laser-based systems such as Multiple Integrated Laser Engagement System (MILES) for Real Time Casualty Assessment (RTCA). However, this laser-based approach requires line-of-sight (LOS) between emitter and sensor to match a shooter with a target for a given direct-fire event (shot pairing) and is, therefore, inadequate for non-line-of-sight shot pairing. This is especially critical in light of the new generation of small arms currently under development, such as the Objective Individual Combat Weapon (OICW). The advantage provided by weapons of this type is the use of laser range-finding and smart munitions to defeat hidden targets, in defilade, or otherwise out of direct LOS. Currently, no instrumentation system exists for shot pairing between individual dismounted combatants using or being engaged by these new weapons, yet these new weapons must, in the near future, be integrated into the training environment.

In light of this situation, U.S. Army STRICOM (Simulation, Training and Instrumentation Command) initiated a study to evaluate the ability of current and future technology to provide a solution to this problem through an emerging technique known as Geometric Pairing (GP). The basic premise of GP is the calculation of the point of impact or detonation of a round based on knowledge of the position of the shooter and target, the time of trigger pull, the orientation vector of the weapon, and the characteristics of the weapon and round fire. Hardware devices are currently available to measure location and pointing vector, but they possess inherent inaccuracies which, though relatively small, combine to create errors in the determination of the point of explosion. These errors increase significantly with distance down-range, thus limiting the effective range of a GP system. This paper will present a discussion of specific technical challenges related to the capabilities and shortcomings of current and emerging GP technology and an analysis of the uncertainties related to the instrumentation.

THE ACCELERATED COMBAT TIMELINE

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The Air Force Wargaming Institute together with TASC, INC. is developing a two-sided simulated war game to allow players to input a joint high-level campaign plan and to see results of the plan after many days of warfare, with no reduction in the fidelity of the simulation. This new innovative tool set is called the Accelerated Combat Timeline (ACT). It consists of a Graphical User Interface (GUI), which currently permits entering the air portion of a joint plan, together with an Air Tasking Order (ATO) Generator, a Situation Display and a Situation Evaluator. The player enters the air campaign plan by specifying prioritized target sets, as well as an apportionment and an allocation for the friendly aircraft. The ATO Generator incrementally plans 24 hours of aircraft sorties. As the battle progresses through these 24-hour increments, the Situation Display is used to view statistics about the campaign. The Situation Evaluator analyzes the current situation against player-input evaluation criteria and advises the player when contingency situations arise that might warrant a revised plan. At the end of each 24-hour cycle, the player has the option to pause the game, rewind to a previous point in time and modify the campaign plan. Currently, ground and naval orders enter the game via a separate user interface for each side. Future plans call for the inclusion of a ground and naval order generator to match the air order generator.

The current simulator engine is the data driven ACES model used at AFWI. It is capable of modeling the battle to any fidelity that is demanded by the user. However, the ACT system is modular in design so that other standard adjudication simulations can be used through customized translations from ACT's strategic inputs to the tactical orders required by most simulations.

DECISION ANALYSIS TECHNIQUES FOR SIMULATION BASED ACQUISITION

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Simulation Based Acquisition (SBA) is an emerging approach for DoD systems acquisition. SBA can be applied to a number of acquisition areas, and should be considered as a candidate strategy or best practice for training systems acquisition. In particular, since training systems often directly include a simulation component, the potential benefits from SBA may be even more significant for training systems acquisition than for other types of systems. It is generally accepted that SBA must be supported by a collaborative information technology environment built around integrated design tools, product and process databases, models, and simulations. Much of the ongoing research in support of SBA has emphasized these technical aspects of the environment. Less attention has been given to a key decision-making issue for SBA:

Given that an SBA environment may be expected to produce substantial amounts of modeling and simulation results, and will provide ready access to extensive design data, how can system designers and program decision-makers make the most effective use of these modeling and data access capabilities?

Unless an SBA environment includes specialized tools to facilitate the manipulation and analysis of results, and to assist decision-makers in reaching a consensus regarding selections among system alternatives, the additional data available under SBA may simply overwhelm decision-makers and have little real impact. This paper reports the results of an investigation to identify, and to experimentally evaluate, candidate data analysis and decision-making techniques for use within SBA environments. It seems clear that, in addition to requiring effective techniques for the post-analysis of model results, SBA will also require specialized tools and techniques for shaping, defining, and quantifying the "decision space" very early in the analysis and design process.

This research involves a series of experiments in which groups of experts apply different pre- and post- analysis methods to a small scale but realistic design problem – in this instance, the design of a notional missile. Data typical of what may be expected from future SBA environments are presented to experts in missile design, using tools and presentation formats appropriate to each technique being evaluated, and are then applied by the experts to reach missile design trade-off decisions. After each experiment, the experts' conclusions as to the effectiveness of each technique, in comparison to their experience with current (non-SBA) design practices, are documented using both individual questionnaires and group consensus methods. This paper describes the overall experimental process and reports the comparative effectiveness of the different SBA-oriented decision techniques evaluated. The results should be applicable to any organization engaged in building an SBA environment or pursuing SBA approaches for training systems development.

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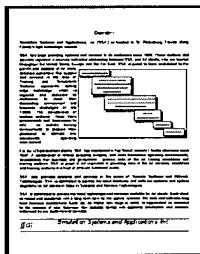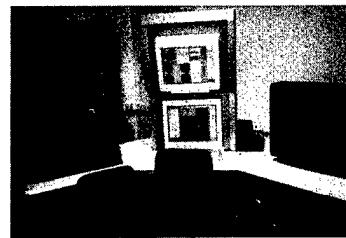
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